BULLETIN OF THE

LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Mass.

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Catalogue Issue

1965-1966

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LOWELL TECHNOLOGICAL INSTITUTE

1965-1966 CATALOGUE

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LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Massachusetts 01854

Established 1895

Operated by the Commonwealth of Massachusetts

Day programs leading to B.B.A., B.S., M.S., and Ph.D. degrees

Evening programs leading to A.B.M., A.A.S., A.S., and A.Eng. degrees

Member of, or approved by, American Chemical Society, American Council on Education, College Entrance Examination Board, Engineers' Council for Professional Development, Massachusetts Department of Education, New England Association of Colleges and Secondary Schools

Total enrollment — 5500
  Day Division — 1900
  Evening Division — 2500
  Summer School — 1100

Men and women students from 20 states and 30 countries

Tuition: $200 for U. S. citizens who are residents of Massachusetts
  $600 for all others

L.T.I. Research Foundation conducts research and development work for government and industry.

The main campus lies between Mass. Route 113 and the VFW Highway along the bank of the Merrimack River, one-half mile north of the center of Lowell, 25 miles north of Boston.

Office hours: 8:30 a.m. — 5:00 p.m., Monday through Friday

Telephone number: 454-7811 (Area Code 617)

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The Board of Trustees reserves the right to waive, at its discretion, any of the rules and regulations stated herein and to change any of the subjects or curricula, or portions thereof, without prior notice.

ACADEMIC CALENDAR, 1965-1966

September 7, Tuesday	Registration of graduate students begins.
September 8, Wednesday	Freshman Orientation Week begins.
September 13, Monday	Registration of seniors and juniors.
September 14, Tuesday	Registration of sophomores.
September 15, Wednesday	Classes begin.
September 21, Tuesday	Last day to register for new classes.
October 12, Tuesday	Columbus Day. Institute closed.
October 15, Friday	Last day to drop classes without penalty.
November 11, Thursday	Veterans Day. Institute closed.
November 24, Wednesday, 12 NOON	Thanksgiving recess begins.
November 29, Monday	Classes resume.
December 15, Wednesday	Friday schedule of classes.
December 17, Friday, 12 NOON	Christmas recess begins.
January 3, Monday	Classes resume.
January 13, Thursday, 8 A.M.	Freshman examinations begin. (All other classes continue)
January 14, Friday	Other first-semester examinations begin.
January 20, Thursday	End of first semester.
January 25, Tuesday	Registration of freshmen.
January 27, Thursday	Registration of juniors, seniors, and graduate students.
January 28, Friday	Registration of sophomores.
January 31, Monday	Classes begin.
February 4, Friday	Last day to register for new classes.
February 22, Tuesday	Washington's Birthday. Institute closed.
March 1, Tuesday	Last day to drop classes without penalty.
March 18, Friday, 12 NOON	Spring recess begins.
March 28, Monday	Classes resume.
April 8, Friday	Good Friday. No classes.
April 18, Monday	Tuesday schedule of classes.
April 19, Tuesday	Patriots Day. Institute closed.
May 13, Friday	Last day for submitting graduate theses.
May 18, Wednesday	Friday schedule of classes.
May 19, Thursday	Second-semester examinations begin.
June 3, Friday	End of second semester.
June 5, Sunday	Baccalaureate and Commencement.

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Theresa D. Leblanc, Secretary

Dean of Students' Office

Barbara Jean Maccaron, Secretary

Division of Chemistry and Applied Chemistry

Harriet E. Burns, Secretary
Mona M. Davis, Secretary
Frank B. Ridge, Chemical Storekeeper

Division of Evening Studies

Caroline C. Dimitriou, Secretary
Ann V. Lenihan, Clerk
Luke E. McCarthy, Recorder

Division of General Studies

Joanne M. Poitras, Secretary

Division of Physics and Engineering Science

Joan Cinq-Mars, B.S., Secretary

Roy M. Cowdrey, B.S.
Eleanor M. McKenna, Secretary
Leo F. Patenaude, Electronics Equipment Supervisor

Graduate School Office
Anita B. Lacie, Secretary

Guidance
John J. MacLaughlan, Ph.B., A.M., Director

Health Services
Arlene D. Gordon, R.N.
(Local physicians and specialists as required)

In-Service Training Program
John J. Delmore, Administrative Assistant

Libraries
Howard K. Moore, A.B., A.M., Ph.D., Director
Joseph V. Kopycinski, B.S., M.S., M.S. in Library Science, Librarian
Charles F. Donaldson, Library Assistant
Ruth B. Fitzgerald, Senior Library Assistant
Mary P. Frascarelli, Library Assistant
Eleanor T. Lessard, Library Assistant
Vera Boyd Meehan, B.S., Senior Library Assistant
Ann V. Pendergast, Library Assistant
June E. Traverse, Library Assistant

Placement Office
Michael J. Taylor, B.A., Director of Placement
Carole A. Asadoor, Clerk

President's Office
Helen G. Flack, S.B., Executive Secretary
Elizabeth P. Kennedy, C.P.S., Secretary

Receptionist
Lorraine I. LeDoux

Registrar's Office
Walter M. Drohan, A.B., A.M., Registrar
Mary P. Kloppenburg, Clerk
Nora M. MacBrayne, Secretary
Mabel M. Murphy, Clerk
Catherine P. Ouellette, Clerk

Special Services
Anita B. Lacie, Secretary

Summer School
Ernest P. James, B.T.C., M.S., Director

GENERAL INFORMATION

History

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry.

In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of leather chemistry, paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, mathematics, nuclear science, nuclear engineering, industrial management, business administration and meterology.

In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to the Lowell Technological Institute. The Institute grants Bachelor of Business Administration, Bachelor of Science, Master of Science, and Doctor of Philosophy degrees.

Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

Accreditation

The Institute is a member of the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends accreditation to the curricula in electrical, mechanical, and textile engineering, and the chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. Although the majority of its students are men, the Institute is coeducational.

Campus

The Institute is located 25 miles north of Boston in Lowell, Massachusetts, a city of nearly 100,000, long famous as a textile center and more recently noted for its increasingly diversified industries. The 25-acre campus, situated on the Merrimack River, includes eleven main buildings, among them the library, an auditorium-administration building, six classroom-laboratory buildings, two residence halls, and a power plant. A $4,500,000 nuclear center and a $2,120,000 physical education building are under way.

Alumni Memorial Library

The library, dedicated to alumni of the Institute who served in World Wars I and II and the Korean conflict, was erected in 1951 by the Alumni Association through contributions from alumni and friends. Besides a book stack capacity of 80,000 volumes, it contains student activity offices and alumni headqurters and houses one of the world's most complete collections of textile books as well as numerous special collections in the fields of paper, leather, and plastics. It also serves as a depository for U. S. government publications and is available to industrial concerns through its Industrial Corporate Membership program.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than $10,000,000. It includes such varied apparatus as an electron microscope, analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, plastics, leather, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Admissions Office has received senior grades for this period. The responsibility of having these marks forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure not less than 12 months in advance of the expected date of enrollment.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Director of Admissions.

Applications for admission must be received by the Institute on or before June 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is in need of financial assistance may request an application for a loan under the National Education Defense Act or an application for scholarship aid AFTER he has been accepted for admission to Lowell Technological Institute.

Application Procedure

A candidate for admission should:

1. Complete the first two pages of the admission application form.

2. Attach a certified check or money order in payment of the application deposit of $10 (see Student Expenses for explanation).

3. Submit the entire application form to the office of his secondary-school principal, with a request that the office fill out pages 3 and 4 and mail the completed application directly to the Director of Admissions.

4. Request transcripts be sent to Lowell Technological Institute from any college, preparatory school, or institution of learning beyond secondary school that he has attended.

5. Make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test which is required of all applicants for admission to the freshman class at the Institute. The applicant must take the Scholastic Aptitude Test

during his senior year in secondary school or thereafter. Letters, telephone calls, etc., will not be accepted in place of the official score card.

Applicants for admission who are in the upper 20% of their high-school class scholastically may be admitted by the Director of Admissions prior to their completion of the C.E.E.B. examinations. This examination, however, must be completed during the senior year and the results forwarded to Lowell Technological Institute before final acceptance is granted.

6. Undergo a complete health examination by his family physician. The physician must return to the Director of Admissions, in duplicate, on forms provided by the Institute, a certificate of good health, indicating the date of the examination. Health certificates are not sent to the applicant until he has been finally accepted by the Institute.

7. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of his place of residence. The certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

8. Upon receipt of his letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll.

Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition.

If an applicant plans to attend the Institute, after receiving his final acceptance letter he should instruct his secondary school to send a transcript of his final grades to the Admissions Office after his graduation.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus days. Personnel from the Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. This year they will be held on October 22, 1965, and on February 24, 1966 and April 22, 1966, commencing at 10:30 a.m. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Entrance Certificate Board, the Regents of the State of New York, or a board of equal standing.

2. For all courses except Business Administration a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiency in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration a candidate must have completed 16 units of approved high-school work (English 4, mathematics 2, American history and social studies 2, laboratory science 1, foreign language 2, electives 5) as well as the Scholastic Aptitude Test. He should also indicate his choice of this program on the top right-hand corner of the formal application form.

In evaluating credits offered for admission, the Institute is guided primarily by the quality of the scholastic record of the applicant and by his promise on grounds of intellect and character. Therefore, an applicant whose preparation has not followed the normal pattern with respect to the accumulation of unit credits should not hesitate to apply for entrance, provided that the quality of his scholarship gives evidence of ability to do college work and provided that he is recommended by his school.

Admission with Advanced Standing

Transfer students must file a formal application for admission to the Institute and must answer yes" to question 6(b) on page 1 of the application. This must be received prior to April 1 of the year in which the student wishes to matriculate.

Transfer credit is given for courses satisfactorily completed with a grade of C or better which are the equivalent in quality and scope of those given at the Institute. Final decision on transfer credit rests with the appropriate division chairman and the Director of Admissions.

Transfer students who have not taken the Scholastic Aptitude Test of the College Entrance Examination Board for matriculation at their previous college may be required to do so. It is the responsibility of the transfer student

to ascertain from the Admissions Office the procedure to be followed prior to his acceptance.

Transfer credit for subjects taken prior to admission to the Institute will not be given any student after his matriculation.

Students from Other Countries

All foreign applicants for whom English is a second language and who have been in the United States for less than two years must take an English proficiency test and have the results sent to the Director of Admissions prior to filing a formal application with the Institute. This test has been furnished to American consular officers by the Department of State. Students should arrange to take that Department's English language examination and request that the results be sent to Lowell Technological Institute. When for any reason it is not possible to take the consular examination, the applicant should make arrangements with the Director of Admissions to take tests recommended by Lowell Technological Institute.

The Institute accepts every year foreign applicants in each class in numbers up to 5% of that class. In all other respects, the admission procedure for foreign students is the same as that required of U. S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, in English, not less than twelve months in advance of the expected date of enrollment. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U. S. students.

To facilitate their adjustment to campus life, all freshman male students from other countries are required to live in the Institute's residence halls and are assigned to rooms shared by U. S. students. Students must supply their own towels, sheets, pillows and pillowcases, and blankets or may subscribe to a laundry service. Bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.

Coronation of Ball Queen

Student-Faculty Seminar

STUDENT HOUSING AND SERVICES

Residence Halls

All male freshmen not living at home are required to live in the residence halls on campus unless they are excused in writing by the Dean of Students. Excuses are reviewed at the beginning of each semester and may be cancelled, should conditions warrant.

Application for permission to occupy other living quarters must be made by letter to the Office of the Dean of Students.

Permission is accorded in cases where the student lives a reasonable distance from the Institute, where financial hardship would be involved through living in a residence hall.

Although rooms are furnished by the Institute, students must take care of them. Each student must supply his own sheets, pillow and pillowcases, blankets, towels, and personal linens or may subscribe to the laundry service provided to all resident students at cost. Each occupant of a room is responsible for damage which may result to furniture or equipment.

Room assignments in residence halls are made for the full academic year. A change of room is not permitted except in rare instances and may be accomplished only after formal application for the change is approved by the Dean of Students.

Rental charge for each residence room is made for the academic year. While the charge covers occupancy only during periods when the Institute is in regular session, it may, at the discretion of the Institute, be extended to include vacation periods.

Room assignments are made as equitably as possible and in the order that applications are received. The Dean's Office supplies a list of approved rooming houses where students may reside who are unable to be placed in residence halls.

Students are cautioned to make no legal agreements nor sign residence leases with persons outside the Institute.

Dining Hall

A cafeteria and a snack bar are available in the residence halls, but use of campus dining facilities is not compulsory.

Health Service

The dispensary is in charge of a registered nurse for eight hours each school day. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to take in case of illness. Medical services are available to students 24 hours daily. There are three excellent modern

hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

If a student requires emergency surgical treatment, every effort is made to communicate with his parent or guardian. Failing this, such action is taken as appears to be necessary in the interest of the student.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance also is available, on a voluntary basis, through the Office of the Dean of Students.

Guidance

The guidance program, under the supervision of the Dean of Students' Office, starts with the admissions procedure and continues throughout the freshman year. During registration, a testing program is conducted, results of which are used to supplement the student's scholastic record and his College Entrance Board examinations. During Orientation Week, the freshman attends a series of lectures whose purpose is to help him in his adjustment to college requirements.

Each freshman is assigned by the Director of Guidance to a faculty member who is his primary contact with other phases of the guidance program. This adviser, who is also a freshman instructor, arranges individual consultations and provides advice and referral help in scholastic, financial, personal, or health problems.

Other phases of the guidance program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions. In the second semester of the freshman year a series of lectures is offered to help the student to become aware of the curricula at the Institute and to determine what course he should elect for the next three years.

Guidance in the upper classes is generally conducted in scholastic matters by the head of the department concerned and in personal problems by the Director of Guidance.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A student may be dropped from the rolls whenever it is considered in the best interests of the Institute.

In some laboratories students are required by state law to wear safety eyeglasses, which may be purchased at the LTI Bookstore. The instructor in each class requiring the use of such eyeglasses will inform the students of the necessity of using them.

Disciplinary Action

Disciplinary action may be in the form of censure, restriction, suspension, or dismissal, according to the measure of an offense. Whenever such action is taken, notation of the penalty is made a part of the permanent record of the student.

Attendance

All students must attend all classes, although a limited number of absences is permitted. Attendance is taken at all classes. Students charged with unexcused absences, particularly immediately before and after holiday and vacation periods, are subject to disciplinary action.

Academic Grades

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.30	(97-100)	C+	2.30	(77-79)
A	4.00	(93-96)	C	2.00	(73-76)
A—	3.70	(90-92)	C—	1.70	(70-72)
B+	3.30	(87-89)	D+	1.30	(67-69)
B	3.00	(83-86)	D	1.00	(63-66)
B—	2.70	(80-82)	D—	0.70	(60-62)
F	0	(below 60)			

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester is obtained an the same manner as the computation for the rating of a single semester.

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

In order that a student be classified "clear", he must achieve the following minimum semester ratings:

first-semester sophomore	1.45	first-semester junior	1.55
second-semester sophomore	1.50	second-semester junior	1.60
first-semester senior	1.65		

A student must achieve the following cumulative ratings:

beginning of sophomore year	1.40
beginning of junior year	1.50
beginning of senior year	1.60

Probation and Dismissal

A student is placed on probation when his semester rating is below 1.35. A student who fails to achieve the required cumulative rating shall be placed on probation. The probationary period covers the entire semester following the issuance of the semester or cumulative rating which placed the student on probation.

A student on probation may not represent the Institute in any public function or any extracurricular activity and my not hold any class office or other office during his term of probation. If a student receives a semester rating below 0.70, he is automatically dropped from the Institute without benefit of a probationary period. A student with a semester rating of less than 1.35 for two consecutive semesters is dropped from the Institute for at least one semester. If a student is dropped for either of the last two reasons, he should plan to take courses at some other college before applying for readmission at LTI.

A student on academic probation will be dropped from the Institute for at least one semester if during his probationary semester he fails to achieve the required semester rating.

Requirements for Graduation

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in a major subject.
2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors—graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors—graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors—graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION DEPOSIT $10

This is payable by certified check or money order and is filed with the Director of Admissions at the time of application.

1. If the applicant is accepted for admission and is duly enrolled as a student at the Institute, the entire amount of this deposit is credited toward his tuition charges on the day of registration.
2. If the applicant is not accepted for admission, the entire amount of the deposit is refunded.
3. If the applicant is accepted for admission but does not choose to enroll, no refund is made.
4. If the applicant is accepted for admission but is called to duty in the armed forces of the United States, he is entitled to a refund of the entire amount of the application deposit.
5. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days of the date upon which the applicant is accepted for admission. For Massachusetts residents this amounts to $50. This prepayment is forfeited if the student fails to register at the Institute. In rare instances, such as sickness which would prevent the applicant from enrolling, this rule may be waived by the Dean of Students.

TUITION

	(per year)
U. S. citizens who are residents of Massachusetts	**$200**
All others	**$600**

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

U. S. citizens who are residents of Massachusetts . . **$10.00 per cr. hr.**

All others . . . . **$30.00 per cr. hr.**

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.
2. The residence of a minor follows that of the parents, unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evadence of emancipation.
3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.
4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.
5. The residence of a wife follows that of the husband.
6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.
7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.
8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

Note: Wherever mentioned above, the word residence means legal domicile.

ROTC DEPOSIT $25

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the amount on deposit, he must pay the charges and make an additional deposit of $25.

ACTIVITY AND INSURANCE FUND $49

Each student enrolled in 10 or more total credit hous must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

RESIDENCE HALLS

The residence hall charge is at the rate of $700 per room for the academic year, this sum to be divided equally among all occupants of the room (two to four students). One-half of the charge is payable by each occupant at the beginning of each semester.

LATE REGISTRATION FEE $5

A student who does not complete his registration (including the payment of all fees) by the close of the registration period must pay this additional fee.

AUDITING FEE . . . . $5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay $5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE $15

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

OFFICIAL TRANSCRIPT FEE $1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of $1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

Laboratory equipment may not be removed from the premises except by special permission.

REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks At least	But less than	Refund Rate
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over		None

SUMMARY OF EXPENSES PER YEAR

Tuition	
U. S. citizen who are residents of Massachusetts	**$200**
All others	**$600**
Residence halls	**$700 per room,** divided equally among occupants (2 to 4)
Student activity and insurance fund	**$ 49**
ROTC deposit	**$ 25**
Books, supplies, and related miscellaneous expenses (approximate)	**$100**

There is no set boarding fee, but a cafeteria is available for meals on a cash basis.

FINANCIAL AID

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time.

At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Director of Admissions before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must also make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/ or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Albany Felt Company Scholarship

One annual grant of $500 to a freshman entering the Institute is made by the Albany Felt Company. Each recipient is given an opportunity for summer employment at the company while in college.

Alumni Association Scholarships

The L.T.I. Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from the following sources:

Stephen E. Smith Scholastic Fund

James T. Smith Fund

Arthur A. Stewart Memorial Scholarship Fund

Warwick Chemical Foundation in memory of Walter Nowicki

New York Chapter, L.T.I. Alumni Association

Berkshire Hathaway, Inc. Scholarships

A number of scholarships covering tuition and living expenses for four years are offered in Textile Engineering and Textile Technology by Berkshire Hathaway, Inc., Providence, R. I. Male employees and sons of employees only are eligible. Students interested should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence, R. I.

Russell L. Brown Scholarship, donated by Davis and Furber Machine Company

This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipened is $300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship

This $200 scholarship is awarded to the male student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship

This $250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships

The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is $200, and each is renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of $250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and the scholarships are renewable on the condition that satisfactory grades are maintained.

Paper Engineering Department Scholarships

Five scholarships, each amounting to $2000 over the four-year period, are available to incoming freshmen who plan to enroll in the Paper Engi-

neering program. Scholarship holders receive annual stipends of $500 provided they maintain good academic standing.

Present contributors to this scholarship program include the following:

Carter, Rice, Storrs & Bement, Inc.
Crane & Company, Inc.
Crocker, Burbank & Co., Association
Dennison Manufacturing Company
Erving Paper Mills
Fraser Paper Ltd.
Hollingsworth & Vose
International Paper Company
Ludlow Corporation
Mohawk Paper Mills
Nashua Corporation
Oxford Paper Company
Paper Management Association, Connecticut Valley Division
Riegel Paper Corporation
Tileston & Hollingsworth Company
Triangle Foundation
S. D. Warren Company

Sylvan I. Stroock Scholarship, donated by S. Stroock & Co., Inc.

A $500 scholarship is awarded each year on the basis of scholarship, financial need, leadership, and promise of success in textile fields from funds established by S. Stroock & Co., Inc.

Science Count-Down Scholarship

A one-year tuition scholarship is available annually to a student who has won first place in Science Count-down, the televised science quiz for Massachusetts eighth-grade pupils, cosponsored by the Institute and WBZ-TV, the Westinghouse Broadcasting Company television station in Boston.

United Elastic Corporation Scholarships

Scholarships of $250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Mass.; West Haven, Conn.; and Stuart, Va.

United States Rubber Company Foundation

This Foundation has established scholarships for students who have successfully completed at least two years of college in which they have demonstrated leadership, capacity for higher education, and a recognition of its cultural and economic value. Applicants must be in need of financial assistance, and recipients assume a moral obligation to repay over a reasonable period at least 25% of the scholarship aid received.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, is available to an undergraduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

AVAILABLE TO UPPERCLASSMEN ONLY

Allied Chemical Foundation Scholarships

Two grants of $750, given by the Allied Chemical Corporation, are awarded to worthy students majoring in Textile Chemistry or Textile Engineering.

Arthur Besse Memorial Scholarship

The Arthur Besse Memorial Trust awards a $500 scholarship each year to a student majoring in textiles and planning to continue in that industry after graduation. The award is based on need, scholarship, and qualities of character and leadership, and it is renewable under the usual academic conditions.

A.S.T.M.E. Awards

Merrimack Valley Chapter 113, American Society of Tool and Manufacturing Engineers, awards $100 annually to a junior-class member in good standing of the Student Chapter on the basis of leadership, scholarship, need, and contribution to the Society. The A.S.T.M.E. Student Chapter presents the Prof. J. Arthur Ainsworth award of up to $100 annually to any chapter member in good standing on the same terms.

Boston Paper Trade Association Scholarships

Two scholarships, each for $150, are open to sophomores, juniors, and seniors enrolled in Paper Engineering who are residents of New England. Awards are based on scholarship and character.

Chemstrand Corporation Scholarship

A scholarship of $500 is available to a superior, deserving student enrolled in textiles. Donor is the Chemstrand Corporation.

DeBell-Richardson Scholarship

DeBell-Richardson, Inc., the D. & R. Pilot Plants, Inc., and John M. DeBell have established a scholarship for a student majoring in Plastics Technology. It is awarded on the basis of scholastic success, extracurricular activities, and financial need.

Dixie Cup Scholarship

The Dixie Cup Division of American Can Company of Easton, Pa., has established a scholarship in the amount of $500 per year. Students majoring in Chemical Engineering, Electrical Engineering, Mechanical Engineering, Paper Engineering, or Plastics Technology are eligible to apply, and selection is based on scholastic achievement, financial need, and extracurricular participation. The Company provides summer employment for the student holding the scholarship.

Foster Grant Scholarship

The Foster Grant Company, Inc. of Leominster, Mass., makes available on a one-year basis a tuition scholarship to a deserving student in Plastics Technology who is a resident of Massachusetts. Preference is given to a sophomore living in the Leominster area; however, if there are no applicants from that area, another candidate may be chosen. Scholarship, personality, and over-all student contribution to extracurricular activities are the general criteria used in selecting the recipient.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of $75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

New England Paper Merchants Association Scholarship

A $100 scholarship is open to a sophomore, junior, or senior in Paper Engineering who is a resident of New England. It is awarded on the basis of scholarship and character.

NOPCO Chemical Company Scholarship

The NOPCO Chemical Company of Newark, N. J., has established two $250 scholarships open to students majoring in Chemical Engineering, Chemistry, Paper Engineering, Plastics Technology, or Textile Chemistry who have proved themselves scholastically and who are active in extracurricular programs.

Society of Plastics Engineers Scholarship

A scholarship is granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to an upperclassman majoring in Plastics Technology.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust

for Charitable Purposes, scholarships are awarded annually and are renewable under the usual conditions. The scholarships cover tuition and books. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and leadership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

AVAILABLE TO GRADUATE STUDENTS ONLY

Teaching Fellowships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends range from $2000 to approximately $2500, depending on the nature of the appointment, and reappointment in succeeding years is contingent upon satisfactory performance of duties. Appointees are expected to carry up to a half-time teaching load primarily involving supervision of undergraduate laboratories and review sections. All applicants for teaching fellowships must take the appropriate Advanced Graduate Record Examination as well as the Aptitude Tests. No special applications are required, but applicants must submit their Graduate School applications, transcripts, and letters of reference to the Director of the Graduate School no later than April 1. In addition, they should plan to take the Graduate Record Examinations in March or earlier.

Research Fellowships

The Lowell Technological Institute Research Foundation sponsors a limited number of research fellowships for graduate study in Physics. A stipend of $2500 plus tuition and fees is granted for one calendar year. The recipient carries a full graduate program during the fall and spring semesters and conducts his thesis investigation during the summer.

All applicants for these fellowships must take the Advanced Graduate Record Examination in Physics as well as the Aptitude Tests. No special applications are required, but applicants must submit their Graduate School applications, transcripts, and letters of reference to the Director of the Graduate School no later than April 1. In addition, they should plan to take the Graduate Record Examinations in March or earlier.

National Science Foundation Cooperative Graduate Fellowships

The Institute is a participant in the National Science Foundation's Cooperative Graduate Fellowship Program. These fellowships are awarded on the basis of ability. Candidates must be citizens of the United States on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute prior to beginning their fellowship tenures.

The stipend provided by the NSF for Cooperative Graduate Fellows is $2400-$2800 for those on a tenure of 12 months and $1800-$2100 for those on a tenure of nine months. There is an additional allowance of $500 for each

non-working dependent, and all tuition and fees are paid directly to the Institute by the NSF.

One of the requirements for applying for an NSF Fellowship is to take the Aptitude Tests and the appropriate Advanced Test of the Graduate Record Examinations. Because the application deadline for these fellowships is in the first part of November, it is important to make arrangements to take these tests early.

Applications for NSF Cooperative Fellowships may be obtained from the Director of the Graduate School or from the Fellowships Section, National Science Foundation, Washington, D. C. 20550.

Textile Salesmen's Association of New York Fellowship

A graduate fellowship in textiles is awarded by the Textile Salesmen's Association of New York, based on academic accomplishment and demonstrated ability. The award is limited to full-time students working toward the M.S. degree in Textile Technology who plan to continue working in the field of textiles in this country after graduation.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of $10 per quarter the first year and $20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

National Defense Education Loans

The National Defense Education Act offers loans to needy students. Repayment begins one year after graduation, unless military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3%, beginning with the first payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry or Paper Engineering. The fund operates under the same conditions as

the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

AWARDS

Awards are made annually at an Honors Convocation conducted by the Scholarship and Awards Committee. A few awards are made at Commencement.

American Association of Textile Chemists and Colorists Book Prize. This is awarded to the outstanding graduating senior in the Textile Chemistry course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemistry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

ASTME Award. The Merrimack Valley Chapter, American Society of Tool and Manufacturing Engineers awards $100 to a member of the Student Chapter of the ASTME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, ,sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years at college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Ben Faneuil Award. An annual award of $100 is made by Mr. Ben Faneuil of The Chelsea Industries, Chelsea, Massachusetts, to the sophomore majoring in Plastics Technology with the highest cumulative average.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of $50 in memory of Profressor Jacob K. Frederick to a freshman, based on scholastic achievement and extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of $250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, formerly of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of $100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry or Textile Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in chemistry.

Phi Psi Award. This award is given to a member of the graduating class who is outstanding in scholastic attainment, leadership, initiative, personality, loyalty, and courtesy.

President's Medal. This award is made to the student who is graduated With Highest Honors for the most distinguished academic record in his class.

Radio Station WLTI Award. The staff of the student-operated radio station WLTI awards a plaque annually to a member outstanding for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

OTHER ASSISTANCE FOR MASSACHUSETTS RESIDENTS ONLY

Board of Educational Assistance Scholarships

These scholarships for one-quarter, one-half, or full tuition are available both to freshmen and to upperclassmen. For full information write to

Executive Secretary
Board of Educational Assistance
200 Newbury Street
Boston 16, Mass.

Massachusetts Scholarship Foundation Scholarships

Awards ranging from $200 to $800 are made for the freshman year only by the Massachusetts Scholarship Foundation. For further information address

Massachusetts Scholarship Foundation
Committee on Awards
1746 Cambridge Street
Cambridge 38, Mass.

Higher Education Loan Plan

Under this HELP plan, students beyond the freshman year may obtain bank loans up to $500 a year upon especially favorable terms. More specific information is available from

Massachusetts Higher Education
Assistance Corporation
1137 Statler Building
Boston 16, Mass.

PLACEMENT

Industrial Training Program

The Placement Office with the assistance of industry endeavors to place qualified underclassmen during summer vacation periods in industries of particular interest to the individual. These training opportunities are open to all students who have completed their sophomore year, except those on scholastic or disciplinary probation.

Objectives of the undergraduate Industrial Training Program are to supply essential industrial experience to the undergraduate, to provide the experience in human engineering only obtained in industry, to enable industry to preview individual students, and to further the liaison between the Institute and industry.

Placement Service

The Placement Office maintains active contacts with many industrial firms throughout the country in each of the fields of concentration presented at the Institute. A complete file of opportunities and data on the various industries and companies is available in the Placement Office to members of the graduating class.

The office arranges for representatives from industrial firms to interview students on campus. In a series of seminars speakers outline the opportunities in particular industries and various positions within the companies.

The office also aids industry in the difficult task of locating experienced personnel and assists alumni to establish new connections. The Placement Office cannot give any graduate a guarantee of employment; however, practically all seniors are placed prior to Commencement every year. No official part-time placement program is in operation because of the heavy academic schedule.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNTY

In addition to the services rendered by the Evening Division, the Alumni Memorial Library, the Research Foundation, and the Summer School program, the college provides such special services to industry and to the community as the following:

Industrial seminars and conferences;

Guidance work in the high schools;

Technorama, science fair for area high schools;

Consultive opportunities with the faculty;

Collaboration with the Agency for International Development of the government in its foreign aid program;

Special radio and television programs, such as Science Count-Down on Boston station WBZ-TV.

For information relative to these programs, address the Coordinator of Special Services at the Institute.

SUMMER SESSION

The Summer Session is designed primarily to serve three principal areas of interest: Professional Advancement Courses for industrial personnel; Undergraduate Credit Courses for college students who require deficiency clearance or who seek advanced standing; and Precollege Refresher Courses for incoming freshmen at L.T.I.

The industry-sponsored professional advancement program comprises a series of specialized, intensive, one- to three-week courses in leather, paper, and textiles. The two six-week undergraduate sessions stress fundamental credit offerings in college mathematics, physics, chemistry, English, economics, electronics, mechanical engineering, accounting, marketing, management, and social studies.

Precollege Refresher Courses

The Precollege Refresher Program is especially designed for prospective L.T.I. students who require additional background to fulfill minimum entrance requirements. Students must first apply for fall admission; the Director of Admissions designates the course or courses required for coverage of minor deficiencies in the high-school background. Five-week, noncredit courses in basic mathematics, physics, chemistry, and English are offered in an Early Session and a Late Session to accommodate all freshman candidates.

For further information or a Summer Session Bulletin, write to the Director of Summer School.

DIVISION OF EVENING STUDIES

The Division of Evening Studies offers five-year associate degree courses in business management, chemistry, leather chemistry, mathematics, paper chemistry, plastics chemistry, radiological health, and rubber chemistry and in the following technologies: electrical engineering, electronic engineering, industrial engineering, and mechanical engineering.

The Graduate School offers a program in the Division of Evening Studies which leads to the Master of Science degree on a part-time basis. The academic requirements for this program are identical with those of the day school. Graduate courses offered in the day or evening programs are interchangeable.

It also offers a program of individual subjects in mathematics, science, technology, engineering, and general studies. These subjects are designed to serve the needs of the community, particularly of those people engaged in industry who wish to further their education.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Division of Evening Studies also offers an In-Service Training Program in Civil Engineering Technology limited to employees of the Commonwealth of Massachusetts and to employees of cities and towns within the Commonwealth.

Research Foundation Laboratory

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. Selected subjects are also offered in an 8-week summer program. For further information, write to the Director of the Evening School.

RESEARCH FOUNDATION

The Lowell Technological Institute Research Foundation is a nonprofit organization authorized under the laws of the Commonwealth of Massachusetts. It was established for the purpose of encouraging and administering research sponsored by industry and government at the Lowell Technological Institute.

Its research projects benefit the educational program of the Institute by enabling both faculty and students to keep abreast of current developments in their respective fields and to develop further their capabilities.

The scientists and engineers of the Foundation's permanent personnel, together with the faculty of the Institute, constitute a staff available for research, development, and testing in the fields of chemistry, electronics, engineering, leather, management, paper, plastics, and physics.

The Research Foundation has its own specialized laboratories and field stations where research ranging from chemical modification of textile fibers to studies of the ionosphere and thermal radiation is performed. The Foundation also uses in in its programs the entire facilities of the Institute. These facilities not only include the usual research tools found in a university or industrial laboratory but also include, in the areas of leather, paper, plastics, and textiles, full-scale and pilot-plant equipment for specialized studies. It is probably the only research organization in the world having at its disposal fully equipped laboratories for processing all types of fibers by all the common manufacturing systems into a finished fabric.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, publishes the official alumni newsletter, and the alumni directory, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum and Evening Division senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of

Directors to any person not an active member who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts or sciences.

Communications should be addressed to the Executive Secretary, Alumni Office, Lowell Technological Institute.

Officers

Joseph E. Weldon '50, President

Edward J. Allard '31, First Vice President

A. Chester Clifford '22, Second Vice President

A. Edwin Wells '20, Clerk and Treasurer

J. Frederic Burtt '31, Assistant Secretary and Student Representative

Charles J. Higgins '54, Executive Secretary of the Alumni Council

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four officers elected by the student body, the president of each undergraduate class, and one representative from each of the classes. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee. In cooperation with the Text, the Council sponsors the annual Jacob K. Frederick Memorial Lecture Series.

Alpine Club

Composed of students interested in mountain climbing, skiing, and associated sports. Numerous weekend trips are scheduled throughout the year. Highlight of the club is the week-long skiing trip during the semester break.

Athletics

The Athletic Association promotes an extensive varsity and intramural sports program. Varsity sports are soccer, basketball, baseball, skiing, tennis, and golf, and competition is mainly with college teams in the northeast section of the country. Intramural sports competition among classes, residence hall students, and fraternities is carried on throughout the year. All students are members of the Association and receive free admission to all intercollegiate contests played at home.

Audio-Visual Society

Objectives of the Audio-Visual Society, composed of students and faculty members interested in this field, are to build and maintain a library of records, recorded tapes, and films, to record special events, and to present various types of audio-visual programs.

Auf Deutsch, Bitte

Informal German conversation marks all meeting of Auf Deutsch, Bitte whose purpose is to foster an understanding of the language, customs, and culture of the German people. Films, music, lectures, and personal anecdotes are featured, and coalition with German clubs of other universities is encouraged.

Band

Band membership is open to all students who possess musical training or wish to learn to play a band instrument. It provides music for AFROTC ceremonies and participates in various college and civic programs.

Barbell Club

This club promotes physical fitness through an intelligently operated weightlifting program.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshmen.

Dormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

Drill Teams

Two AFROTC drill teams, armed and unarmed, are open to all cadets who desire to become proficient in precision drill. Exhibitions are presented at various functions throughout the academic year. The teams compete in the annual spring New York-New England College Drill Meet.

Duplicate Bridge League

Open to students and faculty members, the league conducts ten or more playing sessions each year to determine the champion team. Student members also participate in the annual national Intercollegiate Duplicate Bridge Tournament.

Eta Kappa Nu

To be eligible for membership in this scholastic honor society, one must be an Electrical Engineering major who has participated in campus activities and is of exemplary character. Juniors must be in the upper quarter of their class, and seniors must be in the upper third of their class. The purpose of the organization is to provide a closer union for students majoring in Electrical Engineering who have achieved high scholastic standing, demonstrated leadership in campus activities, and possess outstanding character.

Fraternities

Four fraternities—Delta Kappa Phi, Omicron Pi, Phi Psi, and Pi Lambda Phi— have their own houses to provide centers for social life off campus. Three are national fraternity affiliates. The Interfraternity Council fosters the common interests of the four and sponsors interfraternity social and athletic events.

Hockey Club

This organization operates under the supervision of a faculty coach.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Latin-American Society

This organization unites students of Latin-American origin in a cultural and social program.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the military profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units.

Pickout

The Pickout is the college yearbook. Its staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

- American Chemical Society, Student Chapter
- American Institute of Physics, Student Section
- American Association for Textile Technology, Student Chapter
- American Society of Mechanical Engineers, Student Chapter
- American Society of Tool and Manufacturing Engineers, Student Chapter
- Chemical Engineering Society
- Industrial Management Society
- Institute of Electrical and Electronics Engineers, Student Chapter
- Nuclear Society
- Society for Advancement of Management, Student Chapter
- Society of Plastics Engineers, Student Chapter
- Technical Association of the Pulp and Paper Industry, Student Chapter

Radio Station

WLTI is an all-student enterprise built and maintained by members of the LTI Broadcasting Society. Programs are transmitted by carrier current from the studio to the various campus buildings. By selling air time to local merchants, the station is self-supporting. Its members learn business practices as well as broadcasting and other radio techniques.

Religious Groups

Hillel. The Hillel Counsellorship provides social, cultural, and religious

programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship. Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Club. The Newman Club conducts programs of a social and religious nature for Catholic students at the Institute and at Lowell State College.

Phanar Club. This is composed of Greek Orthodox students from Lowell State College and L.T.I.

Skindiving Club

Non-divers are taught the safety measures involved by experienced divers who also skindive as a group.

Sorority

Phi Sigma Rho, the campus sorority, provides a center for the social life and association of the young women enrolled at the Institute.

Sports Car Club

This club promotes the safe, courteous, efficient, and skillful operation of sports cars on the highway and is a source of information for members.

Swim Club

This club operates under faculty supervision.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

T.O.C.

The Tech Orientation Committee has as its special function the introduction of the new student to college life. T.O.C. plans a month-long series of activities for entering freshmen during the orientation period to enable them to meet one another and to realize their responsibilities to their college.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students.

The bi-weekly publication offers excellent journalistic and business experience to those who work on its staff.

Track Club

Students pursue this sport under faculty supervision.

Vandenberg Air Squadron of the Arnold Air Society

The Vandenberg Air Squadron, a chapter of the national Arnold Air Society, unites selected advanced AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs and air space exhibits during the year. The Military Week End, annual highlight of its program, features a colorful drill ceremony and is climaxed by the formal Military Ball at which new members are accepted into the society.

Varsity Club

The Varsity Club is composed of students who have earned letters in the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose is to give academic help to athletes and to foster a lasting friendship among the men participating in athletics.

UNDERGRADUATE PROGRAMS

Fifteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science except the Business Administration program which leads to the Bachelor of Business Administration degree. These fields are:

Business Administration	Nuclear Engineering
Chemical Engineering	Nuclear Science
Chemistry	Paper Engineering
Electrical Engineering	Physics
Industrial Management	Plastics Technology
Mechanical Engineering	Textile Chemistry
Meteorology	Textile Engineering

Textile Technology

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute.

Number following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

THE ELECTIVE SYSTEM

In all curricula an opportunity is afforded the student to elect subjects in addition to those required for graduation. These electives fall into two categories: Technical Electives and General Electives.

Technical Electives give the student a chance to broaden his professional knowledge by taking subjects allied to his main interest or to further his knowledge of a particular phase by taking additional work therein.

General Electives are to be selected from the following subjects. At least two electives must be chosen in the social sciences (SS) and two in languages and literature (LL).

Subjects required in the AFROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects required in the AFROTC program in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

EC	201	Economics I	(3-0)3
EC	202	Economics II	(3-0)3
EC	301	Economic Development of the United States	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
LL	233	Comparative Literature	(3-0)3
LL	234	Shakespeare	(3-0)3
*LL	261-262	Elementary Technical German	(3-0) (3-0)6
LL	263-264	Elementary French	(3-0) (3-0)6
*LL	265-266	Elementary Technical Russian	(3-0) (3-0)6
LL	267-268	Elementary Spanish	(3-0) (3-0)6
LL	363-364	Intermediate French	(3-0) (3-0)6
*LL	365-366	Intermediate Literary and Conversational Russian	(3-0) (3-0)6
LL	367-368	Intermediate Literary and Conversational German	(3-0) (3-0)6
LL	369-370	Intermediate Spanish	(3-0) (3-0)6
LL	436	English Romanticism	(3-0)3
LL	467	Advanced Seminar in Literary German	(3-0)3
LL	471	The Modern American Novel	(3-0)3
LL	472	The Modern British Novel	(3-0)3
LL	473	World Drama	(3-0)3
LL	474	Modern Drama	(3-0)3
LL	482	The American Short Story	(3-0)3
SS	223-224	The United States Since 1865	(2-0) (2-0)4
SS	225 or 226	Europe: 1789 - 1914	(3-0)3
SS	227	Europe: 1914 - 1939	(3-0)3
SS	228	Europe: 1939 to the Present	(3-0)3

SS	301	Government of the United States	(3-0)3
SS	302	Conduct and Control of Foreign Policy	(3-0)3
SS	303 or 304	Psychology	(3-0)3
SS	305 or 306	Sociology	(3-0)3
SS	371 or 372	American Civilization to 1865	(3-0)3
SS	403	World Politics: Principles, Structures, Cases	(3-0)3
SS	459	World Politics: The Central Problem of War	(3-0)3
SS	460	Foreign Aid and Foreign Policy	(3-0)3
SS	464	World Politics: Problems of International Organization	(3-0)3
SS	471	The United States in World Politics	(3-0)3
SS	472	Defense Policy	(3-0)3
SS	477 or 478	Twentieth-Century Russia	(3-0)3
SS	479 or 480	The Far East Since 1900	(3-0)3
SS	481 or 482	The Greeks and Western Civilization	(3-0)3
SS	483	Political and Social Thought: Ancient Times to Early Modern Times	(3-0)3
SS	484	Political and Social Thought: Early Modern Times to Present	(3-0)3
SS	485 or 486	The Romans and Western Civilization	(3-0)3
SS	487	American Political Thought to 1865	(3-0)3
SS	488	American Political Thought Since 1865	(3-0)3
SS	489 or 490	Nationalism and Imperialism Since 1800	(3-0)3

* These subjects are not accepted for credit, except as an overload, in Chemistry, Chemical Engineering, Electrical Engineering, Mechanical Engineering, Nuclear Engineering, and Textile Engineering.

THE AIR FORCE ROTC PROGRAM

The program is designed to qualify for commissions those men who desire to serve in the United States Air Force, and to provide an education that will develop skills and attitudes vital to professional Air Force officers.

The Air Force ROTC Program is divided into two phases: the General Military Course (GMC) the first two college years and the Professional Officer Course (POC) the last two years.

A student may elect to take both the General Military Course and the Professional Officer Course with four weeks of Field Training between the junior and senior year of college, or he may elect to take just the Professional Officer Course with six weeks of Field Training during the summer prior to entry into the course. All students who elect to take the Professional Officer Course must pass a physical examination and qualifying aptitude examination prior to acceptance. Students who elect to take just the Professional Officer Course must successfully complete the six weeks of Field Training. Transfer students may elect the Professional Officer Course by complying with the above requirements.

Uniforms and all equipment and textbooks required for AFROTC work are supplied by the United States Air Force. Students in the Professional Officer Course receive a $40.00 a month retainer fee. Additional financial assistance is available to a limited number of cadets in the four-year program on a competitive basis.

Students who successfully complete the Professional Officer Course are commissioned as second lieutenants in the United States Air Force Reserve. Those who qualify may receive further training after commissioning in scientific skills, pilot or navigator training, or administration. Outstanding seniors who are designated Distinguished AFROTC Cadets may apply for regular commissions and postgraduate education assignments.

GENERAL MILITARY COURSE

FRESHMAN YEAR

First Semester

AS 101 World Military Systems I (1-1)1

Second Semester

AS 102 World Military Systems II (1-1)1

SOPHOMORE YEAR

First Semester

AS 201 World Military Systems III (1-1)1

Second Semester

AS 202 World Military Systems IV (1-1)1

PROFESSIONAL OFFICER COURSE

JUNIOR YEAR

First Semester

AS 301	Growth and Development of Aerospace Power I	(3-1)3

Second Semester

AS 302	Growth and Development of Aerospace Power II	(3-1)3

SENIOR YEAR

First Semester

AS 401	The Professional Officer I	(3-1)3

Second Semester

AS 402	The Professional Officer II	(3-1)3

Subjects required in the AFROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects required in the AFROTC program in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

Field Training

Field Training is held at several combat operational bases where cadets have the opportunity to observe, fly, and live with career personnel. Transportation from the legal residence of the cadet to the Field Training base and return, food, lodging, and medical and dental care are provided by the Air Force. In addition the cadet receives $78.00 per month while at Field Training.

Field Trips

Periodically, the Department of Aerospace Studies conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

Flight Instruction

The Flight Instruction Program (FIP), designed for seniors in the Professional Officer Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio, and weather. The flying phase consists of 36½ hours of flight instruction at government expense.

Contribution to Student Life

Besides the military and academic phases of its program, the Department of Aerospace Studies sponsors various extracurricular activities which are designed to produce a well-rounded cadet. Chief among these is the Arnold Air Society.

Cadet Decorations and Awards

A number of medals are awarded to selected cadets and cadet officers at a special parade and review held each spring. These include the Thomas F. Costello Trophy, the Alumni Medal, the Convair Cadet Award, the Chicago Tribune Awards, the Armed Forces Communications and Electronics Association Award, the Sons of the American Revolution ROTC Award, the Trustees' Medal, the Reserve Officer Association Medal, the Air Force Association Medal, the Air Force Times Award, and the Vandenberg Cup.

In addition, the Department of Aerospace Studies confers several medals and awards for outstanding performance in various fields, among them the Distinguished AFROTC Cadet Awards.

Distinguished AFROTC Graduate Awards are given to outstanding graduates, based on four years of overall academic and military achievement. A recipient of this award may apply for a regular commission as second lieutenant in the United States Air Force.

THE FRESHMAN PROGRAM

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Business Administration * or Industrial Management † take the following subjects:

First Semester

CH	101	Introduction to Chemical Principles	(4-2)4
LL	111	English I	(3-0)3
MA	107	Calculus and Analytic Geometry	(4-0)4
ME	101	Engineering Graphics	(1-2)1
PH	103	Physics	(4-1)4
		Total hours	(16-5)16

Second Semester

CH	102	Introduction to Chemical Principles	(4-2)4
LL	112	English II	(3-0)3
MA	108	Calculus and Analytic Geometry	(4-0)4
ME	102	Engineering Graphics	(1-2)1
PH	104	Physics	(4-2)4
		Total hours	(16-6)16

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. AFROTC students are excused from one hour per week. No academic credit is given for the physical education program.

* The freshman program in Business Administration is given on the next page.

† Majors in Industrial Management substitute EC 201, Economics I (3-0)3, for PH 103, and EC 202. Economics II (3-0)3, for PH 104.

BUSINESS ADMINISTRATION

The specific objective of the curriculum in Business Administration is to provide an undergraduate liberal and professional education for young men and women who have the qualifications and the ambition to be administrators and executives.

The curriculum offers an integration of the traditional liberal arts subjects and those professional subjects which provide the basic foundations of management science. The emphasis in this area is not technical but administrative. A core of business subjects — accounting, economics, finance, business law, statistics, marketing, production — is required of the student. In the junior year the student is permitted limited concentration in one of the following fields: accounting,* economics, finance, marketing, or production. This specialization affords the student a deeper penetration of the area he expects to work in after graduation. It is limited, however, in order not to detract from the broad professional goals of the program as a whole.

* Accounting specialization starts in the sophomore year.

FRESHMAN YEAR

First Semester

BA	141	Accounting I	(3-0)3
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	101	Mathematical Analysis I	(3-0)3
		Science Elective †	3
		Total credit hours	15

Second Semester

BA	142	Accounting II	(3-0)3
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	102	Mathematical Analysis II	(3-0)3
		Science Elective †	3
		Total credit hours	15

† Physics, chemistry, biology. (Two semesters of one science must be taken.)

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. AFROTC students are excused from one hour per week. No academic credit is given for the physical education program.

SOPHOMORE YEAR

First Semester

EC	211	Economic Statistics I	(3-0)3
EC	301	Economic Development of the U.S.	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		Behavioral Science Elective *	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	344	Cost Accounting	(2-2)3
EC	212	Economic Statistics II	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
		Behavioral Science Elective *	(3-0)3
		Total hours	(14-2)15

* Sociology, psychology, or accounting. (Accounting must be taken by students majoring in this subject.)

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
BA	331	Corporation Finance	(3-0)3
BA	361	Business Law	(3-0)3
BA	371	Production Management I	(3-0)3
		Humanities Elective *	(3-0)3
		Business Elective or Aerospace Studies †	3
		Total credit hours	18

Second Semester

BA	322	Marketing Problems	(3-0)3
BA	332	Money and Banking	(3-0)3
BA	372	Production Management II	(3-0)3
EC	302	Labor Economics	(3-0)3
		Humanities Elective *	(3-0)3
		Business Elective or Aerospace Studies †	3
		Total credit hours	18

* English, history, social science, or a foreign language. (A two-year commitment is required for language credit.)

† See list of electives at end of curriculum.

SENIOR YEAR

First Semester

BA	401	International Business Operations	(3-0)3
BA	451	Personnel Management	(3-0)3
BA	481	Insurance	(3-0)3
EC	401	Government and Business	(3-0)3
		Business Elective *	(3-0)3
		Humanities Elective or Aerospace Studies †	3
		Total credit hours	18

Second Semester

BA	452	Industrial Relations	(3-0)3
BA	492	Transportation	(3-0)3
EC	412	Managerial Economics	(3-0)3
		Business Elective *	(3-0)3
		Humanities Elective or Aerospace Studies †	3
		Total credit hours	18

* Business Electives: accounting, economics, finance, marketing, personnel management, and production management. (A student must have 12 hours in one area in order to receive credit for concentration in that area.)

† Humanities Electives: English, history, social sciences, and foreign languages. (A two-year commitment is required for language credit.)

CHEMICAL ENGINEERING

This curriculum is designed to provide the student with a firm understanding of scientific principles as well as practical engineering competence. Graduates are qualified to enter industry or proceed to graduate studies.

A strong background is provided in the sciences in the first two years, with emphasis being placed upon chemical engineering and other engineering subjects in the junior and senior years. Oral and written reports are required in most courses to train the student in clear thinking and sound presentation of engineering facts. The courses of industrial chemistry, unit operations laboratory, and economic balance and plant design in the senior year prepare the student to enter the chemical industry, the petroleum industry, the plastics industry, or graduate work in chemical engineering.

The stability of the chemical industry, coupled with its strong and continued growth, provides the graduate with unrivalled opportunities. The broad training of the chemical engineer permits him to enter research and development, production, sales, and market development areas of business; it also gives him the tools to develop a career which is both challenging and satisfying.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(3-0)3
CHE	203	Introduction to Chemical Engineering	(1-0)1
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
SS	223	The U. S. Since 1865	(2-0)2
		Total hours	(17-5)18

Second Semester

CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-4)4
CHE	204	Industrial Stoichiometry	(3-0)3
EE	324	Electrical Energy Conversion	(3-2)4
MA	206	Differential Equations	(3-0)3
		Total hours	(15-9)18

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CHE	303	Chemical Engineering I	(3-0)3
EC	201	Economics I	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
ME	341	Thermodynamics	(3-0)3
		General Elective or Technical Elective	3
		Total credit hours	19

Second Semester

CH	332	Physical Chemistry	(3-3)4
CHE	304	Chemical Engineering II	(3-0)3
CHE	312	Chemical Engineering Thermodynamics	(3-0)3
EC	202	Economics II	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
ME	262	Machine Tool Laboratory	(1-2)1
		General Elective or Technical Elective	3
		Total credit hours	20

SENIOR YEAR

First Semester

CHE	405	Chemical Engineering III	(3-0)3
CHE	407	Industrial Chemistry I	(3-0)3
CHE	411	Chemical Engineering Laboratory	(0-6)2
MA	383	Statistical Methods	(3-0)3
ME	215	Engineering Mechanics I	(3-0)3
		Technical Elective or AS 402	3
		General Elective	(3-0)3
		Total credit hours	20

Second Semester

CHE	408	Industrial Chemistry II	(3-0)3
CHE	410	Economic Balance and Plant Design	(3-0)3
CHE	412	Chemical Engineering Laboratory	(0-6)2
ME	216	Engineering Mechanics II	(3-0)3
		Technical Elective	(3-0)3
		General Elective	(3-0)3
		General Elective or Technical Elective	3
		Total credit hours	20

CHEMISTRY

The curriculum in Chemistry is designed to provide both a throrough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the Committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

Admission to the sophomore year in the curriculum is contingent upon the student's receiving a minimum average grade of C— in the two semesters of Introduction to Chemical Principles. (CH 101-102) in his freshman year.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	207	Electrolytic Solutions	(2-3)3
CH	209	Analytical Techniques	(1-3)2
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
		Total hours	(14-11)17

Second Semester

CH	202	Organic Chemistry	(3-3)4
CH	208	Inorganic Chemistry	(3-0)3
CH	210	Analytical Chemistry	(3-6)5
MA	206	Differential Equations	
or			(3-0)3
MA	384	Statistical Methods	
PH	206	Physics	(4-2)4
		Total hours	(16-11)19

JUNIOR YEAR

First Semester

CH	321	Organic Chemistry Laboratory II	(0-6)2
CH	331	Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
LL	261	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective or AS 301	3
		Total credit hours	18

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	342	Organic Qualitative Analysis	(1-6)3
EC	202	Economics II	(3-0)3
LL	262	Elementary Technical German	(3-0)3
		General Elective	(3-0)3
		Technical Elective or AS 302	3
		Total credit hours	19

SENIOR YEAR

First Semester

CH	411	Advanced Analytical Chemistry	(2-4)3
CH	443	Advanced Inorganic Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective	3
		Technical Elective or AS 401	3
		Total credit hours	18

Second Semester

CH	444	Advanced Inorganic Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective	3
		Technical Elective or AS 402	3
		Total credit hours	15

Seniors are strongly advised to take CH 423-424 (Advanced Organic Chemistry) or CH 431-432 (Advanced Physical Chemistry) as one of the technical electives. Other technical electives include CH 403-404, CH 407-408, and CH 481.

ELECTRICAL ENGINEERING

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering with emphasis in electronics.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classroom.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences, with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of non-technical knowledge in determining the student's ultimate level of responsibility in professional life.

The criteria used for determining which students from the freshman class seeking admission to major in Electrical Engineering are acceptable as sophomores are as follows:

1. A minimum rating of 2.00 for the second semester of the freshman year.
2. No unremoved failures in freshman subjects.
3. A grade of C (not C—) or higher in MA 108 and PH 104.

SOPHOMORE YEAR

First Semester

EE	201	Introductory Circuit Theory	(3-0)3
EE	205	Basic Electrical Engineering Laboratory	(0-3)1
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	215	Engineering Mechanics I	(3-0)3
PH	253	Introductory Field Theory	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-3)17

Second Semester

EE	202	Introductory Circuit Theory	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	216	Engineering Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	254	Introductory Field Theory	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

EE	301	Electronic Devices/Models	(3-0)3
EE	303	Electromagnetics	(3-0)3
EE	307	Network Analysis	(3-0)3
EE	309	Electronic Devices Laboratory	(0-3)1
MA	311	Engineering Mathematics	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-3)16

Second Semester

EE	302	Electronic Devices/Models	(3-0)3
EE	308	Network Analysis	(3-0)3
EE	310	Electronic Devices Laboratory	(0-3)1
		Two General Electives	(6-0)6
		Technical Elective	(3-0)3
		Total hours	(15-3)16

Technical Electives

MA	312	Engineering Mathematics	(3-0)3
PH	208	Modern Physics	(3-2)4

SENIOR YEAR

First Semester

General Elective (from approved list)	3 credits
EE Technical Electives	8 credits
AS 401 or Elective	3 credits
Minimum credit hours per semester	14

Second Semester

General Elective (from approved list)	3 credits
EE Technical Electives	8 credits
AS 402 or Elective	3 credits
Minimum credit hours per semester	14

INDUSTRIAL MANAGEMENT

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide the student with a foundation in science and engineering, in the humanities, and in the social sciences. In addition, the various aspects of management — business organization, production, distribution, accounting, and finance — are studied. The student extends his knowledge of mathematics to include statistics. He is also introduced to the newer research methods, including operations research, linear programming, and game theory. A graduate of this program can expect to find employment as a specialist in accounting, procurement, administration, technical sales, or personnel management.

FRESHMAN YEAR

First Semester

CH	101	Introduction to Chemical Principles	(4-2)4
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	107	Calculus and Analytic Geometry	(4-0)4
ME	101	Engineering Graphics	(1-2)1
		Total hours	(15-4)15

Second Semester

CH	102	Introduction to Chemical Principles	(4-2)4
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	108	Calculus and Analytic Geometry	(4-0)4
ME	102	Engineering Graphics	(1-2)1
		Total hours	(15-4)15

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. AFROTC students are excused from one hour per week. No academic credit is given for the physical education program.

SOPHOMORE YEAR

First Semester

BA	141	Accounting I	(3-0)3
BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
LL	213	Introduction to English Literature	(3-0)3
ME	263	Metals Processing	(1-2)1
PH	103	Physics	(4-1)4
		Total hours	(17-3)17

Second Semester

BA	142	Accounting II	(3-0)3
BA	324	Industrial Marketing	(3-0)3
EC	212	Economic Statistics II	(3-0)3
LL	214	Introduction to American Literature	(3-0)3
PH	104	Physics	(4-2)4
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

BA	331		Corporation Finance	(3-0)3
BA	371		Production Management I	(3-0)3
IM	351		Motion and Time Study	(0-2)1
ME	315		Applied Mechanics	(3-0)3
ME	377		Elements of Materials Science	(2-0)2
SS	303		Psychology	(3-0)3
			One of the Following Options†	
AS	301	(A)	Growth and Development of Aerospace Power I	(3-1)3
BA	325	(B)	Advertising	(3-0)3
BA	241	(C)	Accounting III	(3-0)3
MA	205	(D)	Calculus and Analytic Geometry	(4-0)4
			Total credit hours	18 or 19

†The specialization sequence selected by the student must be followed through the senior year unless a waiver is granted by the Department Head.

Second Semester

BA	332		Money and Banking	(3-0)3
BA	344		Cost Accounting	(2-2)3
BA	372		Production Management II	(3-0)3
EC	302		Labor Economics	(3-0)3
ME	372		Strength of Materials	(3-0)3
			One of the Following	
AS	302	(A)	Growth and Development of Aerospace Power II	(3-1)3
BA	402	(B)	International Business Operations	(3-0)3
BA	242	(C)	Accounting IV	(3-0)3
MA	206	(D)	Differential Equations	(3-0)3
			Total credit hours	18

SENIOR YEAR

First Semester

BA	451		Personnel Management	(3-0)3
EC	301		Economic Development of the U.S.	(3-0)3
EE	351		Industrial Electronics	(3-0)3
ME	343		Heat and Power	(3-0)3
			Special Major Elective*	(3-0)3
			One of the Following	
AS	401	(A)	The Professional Officer I	(3-1)3
BA	421	(B)	Procurement	(3-0)3
BA	341	(C)	Accounting V	(3-0)3
PH	205	(D)	Physics	(4-2)4
			Total credit hours	18 or 19

*BA 423, 431, 441, 443, 481; EC 303, 401; IM 371, 483, 509; SS 305.

Second Semester

BA	362		Business Law	(3-0)3
EC	402		Government and Business	(3-0)3
EC	412		Managerial Economics	(3-0)3
ME	494		Industrial Instrumentation	(2-0)2
			Special Major Elective*	(3-0)3
			One of the Following	
AS	402	(A)	The Professional Officer II	(3-1)3
BA	426	(B)	Sales Management	(3-0)3
BA	342	(C)	Accounting VI	(3-0)3
PH	206	(D)	Physics	(4-2)4
			Total credit hours	17 or 18

*BA 334, 424, 432, 442, 452, 492; EC 304, 414; IM 484, 504, 510; SS 306.

MECHANICAL ENGINEERING

This course trains the student in the application of the facts and methods of mathematics and science to the design and use of machinery and processes. Principles of design and analysis are stressed in all subjects, and the systems point of view is emphasized.

The student is thoroughly instructed in basic mathematics, physics, and chemistry. There is a unified sequence in applied mechanics which focuses on a course in design given in the senior year. The properties of engineering materials and the principles of thermodynamics, fluid mechanics, and heat transfer are taught, together with a series of subjects in electrical engineering.

In the laboratory the student becomes familiar with design techniques associated with typical energy conversion devices, controls, and instrumentation.

This curriculum is accredited by the Engineers' Council for Professional Development.

Requirements for admission to the sophomore year are a 2.00 cumulative average, no failures or incomplete courses, and a C average or better in freshman mathematics and physics.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
		Total hours	(17-2)17

Second Semester

EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	206	Physics	(4-2)4
		Total hours	(16-3½)17

JUNIOR YEAR

First Semester

ME	263	Metals Processing	(1-2)1
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
ME	375	Materials Science	(3-2)3
		Three General Electives	(9-0)9
		Total hours	(19-4)19

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
MA	356	Digital Computer Programming	(2-2)2
ME	314	Mechanical Engineering Laboratory I	(0-3)1
ME	318	Applied Mechanics IV	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-7)19

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	443	Heat Transfer	(3-0)3
ME	495	Electromechanical Engineering	(3-2)4
		Technical Elective	3
		Technical Elective or AS 401	3
		Total credit hours	17

Technical Electives

ME	431	Power Plant Systems	(2-3)3
ME	455	Information Processing Systems	(2-2)3
ME	471	Experimental Stress Analysis	(2-2)3

Second Semester

EC	414	Engineering Economy	(3-0)3
ME	416	Mechanical Engineering Laboratory III	(0-3)1
ME	492	Engineering Systems	(2-0)2
ME	496	Electromechanical Engineering	(3-2)3
		General Elective	(3-0)3
		Technical Elective or AS 402	3
		Technical Elective	3
		Total credit hours	18

Technical Electives

ME	422	Machine Design	(2-3)3
ME	456	Information Processing Systems	(2-2)3
ME	472	Experimental Stress Analysis	(2-2)3
ME	476	Physical Metallurgy	(3-0)3
ME	528	Kinematic Mechanism Synthesis	(3-0)3
ME	580	Aero- and Astrodynamics	(3-0)3

METEOROLOGY

Starting in the fall semester of 1965-1966, a four-year program leading to the Bachelor of Science degree in Meteorology will be offered. The program is in the final stages of organization and is being designed to train students in the basic fundamentals of atmospheric sciences and prepare them for the many industries and government agencies requiring meteorologists. It is also suitable background for graduate work in the field.

Mathematics, the physical sciences, and some elements of electrical engineering are so essential that during the first two years the program is built on these subjects. The freshman year is the one common to the programs in science and engineering.

In the field of meteorology witll be included such subjects as Survey of the Atmosphere, Dynamic Meteorology, Meteorological Instrumentation, Synoptic Meteorology, Physical Meteorology, Climatology. Much of the work involves laboratory excercises based on the basic theories and probability studies.

Enrollment beyond the freshman year will depend upon the student's receiving a minimum rating of 2.00 for the second semester of the freshman year and grades of at least C in both physics and mathematics.

NUCLEAR ENGINEERING

The Nuclear Engineering course was the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.00, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
		Total hours	(17-2)17

Second Semester

EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
PH	208	Modern Physics	(3-2)4
		Total hours	(15-3½)17

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
NU	301	Nuclear Radiation and Radiological Safety	(3-0)3
PH	363	Introductory Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(18-0)18

Second Semester

MA	302	Advanced Calculus	(3-0)3
ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
ME	476	Physical Metallurgy	(3-0)3
PH	366	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(18-0)18

SENIOR YEAR

First Semester

ME	443	Heat Transfer	(3-0)3
NU	401	Nuclear Engineering	(3-0)3
NU	405	Reactor Theory	(3-0)3
NU	451	Nuclear Instrumentation II	(3-0)3
NU	493	Nuclear Laboratory	(0-6)2
		General Elective	(3-0)3
		Total hours	(15-6)17

Second Semester

CH	484	Nuclear Chemistry and Radiochemistry	(3-3)4
NU	402	Nuclear Engineering	(3-0)3
NU	406	Reactor Theory	(3-0)3
NU	494	Nuclear Laboratory	(0-6)2
PH	462	Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-9)18

NUCLEAR SCIENCE

The course in Nuclear Science was the first to be offered by a publicly supported institution in New England. The curriculum emphasizes those fundamental subjects in physics and mathematics necessary for a basic education in all sciences and thus prepares the graduate for advanced studies as well as for responsible positions in industry.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.00, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

EE	203	Fundamentals of Electricity	(3-0)3
LL	261	Elementary Technical German	
or			(3-0)3
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(17-2)17

Second Semester

EE	204	Introductory Electronics	(3-1½)4
LL	262	Elementary Technical German	
or			(3-0)3
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	242	Modern Physics	(3-2)4
PH	258	Electrical Measurements	(2-3)3
		Total hours	(15-8½)18

JUNIOR YEAR

First Semester

MA 301	Advanced Calculus	(3-0)3
PH 311	Intermediate Mechanics	(3-0)3
PH 321	Intermediate Thermodynamics	(3-0)3
PH 343 or PH 345	Atomic and Nuclear Physics	(3-0)3
PH 353 or PH 355	Electromagnetic Theory	(3-0)3
	General Elective	(3-0)3
	Total hours	(18-0)18

Second Semester

MA 302	Advanced Calculus	(3-0)3
PH 312	Intermediate Mechanics	(3-0)3
PH 324	Introduction to Statistical Mechanics	(3-0)3
PH 344 or PH 346	Atomic and Nuclear Physics	(3-0)3
PH 354 or PH 356	Electromagnetic Theory	(3-0)3
PH 394	Physics Laboratory	(0-3)1
	General Elective	(3-0)3
	Total hours	(18-3)19

SENIOR YEAR

First Semester

MA 433	Matrix Algebra	(3-0)3
NU 301	Nuclear Radiation and Radiological Safety	(3-0)3
NU 451	Nuclear Instrumentation II	(3-0)3
NU 493	Nuclear Laboratory	(0-6)2
	General Elective	(3-0)3
	Technical Elective	3 or 4
	Total credit hours	17 or 18

Technical Electives

MA	543	Partial Differential Equations I	(3-0)3
MA	573	Functions of a Complex Variable	(3-0)3
NU	405	Reactor Theory	(3-0)3
PH	411	Quantum Theory	(3-0)3
PH	471	Solid-State Physics	(3-0)3
PH	511	Classical Mechanics	(3-0)3
PH	557	Electricity and Magnetism	(3-0)3
PH	565	Nuclear and Electron Spin Resonance Phenomena	(3-3)4

Second Semester

CH	484	Nuclear Chemistry and Radiochemistry	(3-3)4
MA	484	Probabilities	(3-0)3
NU	494	Nuclear Laboratory	(0-6)2
PH	462	Nuclear Physics	(3-0)3
		Two Electives	6 or 7
		Total hours	18 or 19

Technical Electives

MA	526	Modern Algebra	(3-0)3
MA	546	Partial Diifferential Equations II	(3-0)3
NU	406	Reactor Theory	(3-0)3
PH	412	Quantum Theory	(3-0)3
PH	472	Solid-State Physics	(3-0)3
PH	512	Classical Mechanics	(3-0)3
PH	524	Low-Temperature Physics	(3-3)4
PH	558	Electricity and Magnetism	(3-0)3

PAPER ENGINEERING

This curriculum has a hard core of chemical engineering subjects coupled with several in pulp and paper manufacture and the converting of paper. Emphasis is placed on the engineering and design aspects of this branch of engineering science. Graduates may go directly into industry or may continue with graduate studies either in Paper Engineering or in Chemical Engineering.

As the fifth largest industry in the United States, the paper industry offers employees both stability and excellent opportunities for advancement. The increasing complexity of pulp and paper operations and the growth of paper converting, involving plastics, chemicals, metals, and other materials, have created an intense and growing demand for men with sound engineering training and a basic knowledge of the industry. Graduates of the Paper Engineering course are qualified to enter the paper industry in research and development, production, sales and market development, or management.

The interest of the industry in Paper Engineering graduates is evidenced by the generous scholarships available to students enrolled in this program. Five four-year scholarships amounting to $2,000 for the four-year period are available, and other scholarships are granted based on individual scholastic records.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PA	201	Introduction to Paper Engineering	(1-0)1
PH	205	Physics	(4-2)4
SS	223	The U. S. Since 1865	(2-0)2
		Total hours	(17-5)18

Second Semester

CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-4)4
CHE	204	Industrial Stoichiometry	(3-0)3
EE	324	Electrical Energy Conversion	(3-2)4
MA	206	Differential Equations	(3-0)3
		Total hours	(15-9)18

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
CHE	303	Chemical Engineering I	(3-0)3
EC	201	Economics I	(3-0)3
ME	261	Machine Tool Laboratory	(1-2)1
PA	301	Pulp Systems	(3-0)3
PA	303	Pulp Systems Laboratory	(0-6)2
		General Elective	(3-0)3
		Total hours	(16-11)19

Second Semester

CH	332	Physical Chemistry	(3-3)4
CHE	304	Chemical Engineering II	(3-0)3
EC	202	Economics II	(3-0)3
PA	302	Paper Systems	(3-0)3
PA	304	Paper Systems Laboratory	(0-6)2
		Technical Elective or AS 302	3
		General Elective	(3-0)3
		Total credit hours	21

SENIOR YEAR

First Semester

CHE	405	Chemical Engineering III	(3-0)3
CHE	411	Chemical Engineering Laboratory	(0-6)2
ME	215	Engineering Mechanics I	(3-0)3
ME	341	Thermodynamics	(3-0)3
PA	403	Converting Processes	(3-0)3
PA	405	Converting Processes Laboratory	(0-6)2
		General Elective	(3-0)3
		Total hours	(15-12)19

Second Semester

CHE	312	Chemical Engineering Thermodynamics	(3-0)3
CHE	412	Chemical Engineering Laboratory	(0-6)2
ME	216	Engineering Mechanics II	(3-0)3
PA	410	Advanced Paper Engineering Seminar	(3-0)3
		Technical Elective or AS 402	3
		General Elective or Technical Elective	3
		General Elective	(3-0)3
		Total credit hours	20

PHYSICS

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.00, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

EE	203	Fundamentals of Electricity	(3-0)3
LL	261	Elementary Technical German	
or			(3-0)3
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(17-2)17

Second Semester

EE	204	Introductory Electronics	(3-1½)4
LL	262	Elementary Technical German	
or			(3-0)3
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0)3
ME	264	Metals Processing	(1-2)1
PH	242	Modern Physics	(4-2)4
PH	258	Electrical Measurements	(2-3)3
		Total hours	(16-8½)18

JUNIOR YEAR

First Semester

MA 301	Advanced Calculus	(3-0)3
PH 311	Intermediate Mechanics	(3-0)3
PH 321	Intermediate Thermodynamics	(3-0)3
PH 343 or PH 345	Atomic and Nuclear Physics	(3-0)3
PH 353 or PH 355	Electromagnetic Theory	(3-0)3
	General Elective	(3-0)3
	Total hours	(18-0)18

Second Semester

MA 302	Advanced Calculus	(3-0)3
PH 312	Intermediate Mechanics	(3-0)3
PH 324	Introduction to Statistical Mechanics	(3-0)3
PH 344 or PH 346	Atomic and Nuclear Physics	(3-0)3
PH 354 or PH 356	Electromagnetic Theory	(3-0)3
PH 394	Physics Laboratory	(0-3)1
	General Elective	(3-0)3
	Total hours	(18-3)19

SENIOR YEAR

First Semester

MA 459	Digital Computer Programming and Numerical Analysis	(2-3)3
PH 493	Advanced Laboratory	(1-3)2
	Experimental Elective	3
	General Elective	3
	Two Technical Electives	6
	Total credit hours	17

Experimental Electives

PH 443	Spectrographic Methods	(2-3)3
PH 445	X-Ray Diffraction	(1-6)3

Second Semester

MA	460	Digital Computer Programming and Numerical Analysis	(2-3)3
PH	494	Advanced Laboratory	(1-3)2
		Experimental Elective	3
		Three Approved Electives	9
		Total credit hours	17

Experimental Electives

PH	448	Electron Microscopy and Electron Diffraction	(2-3)3
PH	450	Infrared Radiation	(2-3)3
PH	454	Piezoelectric Crystals	(2-3)3

SENIOR YEAR

(Physics Honors Course)

First Semester

MA	433	Matrix Algebra	(3-0)3
PH	411	Quantum Theory	(3-0)3
PH	493	Advanced Laboratory	(1-3)2
		Solid-State Physics Elective	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	17

Solid-State Physics Electives

PH	471	Solid-State Physics	(3-0)3
PH	565	Nuclear and Electron Spin Resonance Phenomena	(3-0)3

Second Semester

PH	412	Quantum Theory	(3-0)3
PH	494	Advanced Laboratory	(1-3)2
		Mathematics Elective	(3-0)3
		Solid-State Physics Elective	(3-0)3
		Two Electives	6
		Total credit hours	17

Solid-State Physics Electives

PH	472	Solid-State Physics	(3-0)3
PH	524	Low-Temperature Physics	(3-0)3

PLASTICS TECHNOLOGY

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials rather than on the chemical details involved in their synthesis.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics, and quality control augment the basic courses in mathematics, sciences, engineering, and plastics technology to round out a well balanced program.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the International Society of Plastics Engineers, an opportunity which affords each student member an early and rewarding professional association.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
PL	201	Introduction to Polymeric Materials	(2-0)2
		Total hours	(16-5)17

Second Semester

CH	202	Organic Chemistry	(3-3)4
CH	212	Quantitative Analysis	(3-4)4
*MA	384	Statistical Methods	(3-0)3
PH	206	Physics	(4-2)4
PL	202	Introduction to Polymeric Materials	(2-0)2
		Total hours	(15-9)17

*May substitute MA 206, Differential Equations (3-0)3.

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
*EC	201	Economics I	(3-0)3
EE	323	Electrical Energy Conversion	(3-2)4
ME	261	Machine Tool Laboratory	(1-2)1
ME	313	Mechanics of Solids I	(3-0)3
PL	301	Plastics Technology	(2-2)3
		Total hours	(15-9)18

*ROTC students will substitute AS 301.

Second Semester

CH	332	Physical Chemistry	(3-3)4
*EC	202	Economics II	(3-0)3
ME	374	Plastics Mold Design and Construction	(1-2)1
ME	376	Materials Science	(3-2)3
ME	378	Mechanics of Solids II	(3-0)3
PL	302	Plastics Technology	(2-2)3
		Total hours	(15-9)17

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
ME	493	Industrial Instrumentation	(2-0)2
PL	401	Plastics Technology	(2-3)3
PL	403	Properties of Polymers	(0-3)1
PL	411	Plastics Seminar	(1-0)1
PL	413	Introduction to Polymer Physics	(2-0)2
		Two Electives	(6-0)6
		Total hours	(16-10)19

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
ME	382	Fluid Mechanics	(3-0)3
PL	402	Plastics Technology	(2-3)3
PL	404	Properties of Polymers	(0-3)1
PL	412	Plastics Seminar	(1-0)1
PL	414	Introduction to Polymer Physics	(2-0)2
		Elective	(3-0)3
		Total hours	(16-10)19

Suggested Electives

CH	423-424	Advanced Organic Chemistry	(3-0)	(3-0)6
IM	483 or 484	Statistical Quality Control		(3-0)3
LL	261-262	Elementary Technical German	(3-0)	(3-0)6
MA	206	Differential Equations		(3-0)3

TEXTILE CHEMISTRY

The curriculum in Textile Chemistry is designed to provide a sound foundation in the basic principles of chemistry combined with a knowledge of chemical applications in the fiber and textile fields. Graduates are particularly prepared for positions in industrial organizations oriented toward chemicals for textile applications and fiber development and processing.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	207	Electrolytic Solutions	(2-3)3
CH	209	Analytical Techniques	(1-3)2
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics	(4-2)4
TC	201	Introduction to Textiles	(2-0)1
		Total hours	(16-11)18

Second Semester

CH	202	Organic Chemistry	(3-3)4
CH	210	Analytical Chemistry	(3-6)5
MA	384	Statistical Methods	(3-0)3
PH	206	Physics	(4-2)4
TC	202	Chemistry and Physics of Fibers	(3-0)3
		Total hours	(16-11)19

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
TC	301	The Purification of Fibers	(2-3)3
TC	311	Chemical Textile Testing	(3-0)3
TE	471	Textile Evaluation	(2-3)3
		General Elective	(3-0)3
		Total hours	(16-9)19

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	334	Colloid Chemistry	(3-0)3
CH	342	Organic Qualitative Analysis	(1-6)3
EC	202	Economics II	(3-0)3
		General Elective	(3-0)3
		*Technical Elective	3
		Total credit hours	19

SENIOR YEAR

First Semester

CH	411	Advanced Analytical Chemistry	(2-4)3
TC	403	The Principles of Dyeing and Printing	(2-6)4
TC	411	Chemical Technology of Finishing I	(3-1)3
		General Elective	(3-0)3
		*Two Technical Electives	6
		Total credit hours	19

Second Semester

TC	404	Theory of Dyeing	(3-4)4
TC	412	Chemical Technology of Finishing II	(3-2)4
		General Elective	(3-0)3
		*Two Technical Electives	6
		Total credit hours	17

* MA 206 is recommended as the technical elective in the junior year if graduate study is planned.

Technical electives in the senior year must include six credits selected from CH 423-424, CH 431-432, or CH 443-444.

It is recommended that the remaining credits be taken in CH 403-404.

TEXTILE ENGINEERING

This course is based on a sound training in mathematics and science and their application to the solution of technical problems. The curriculum is similar to and related to that in Mechanical Engineering but includes sufficient subjects in textile science to qualify the student for positions in either production or research in the textile industry.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
		Total hours	(17-2)17

Second Semester

EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
ME	264	Metals Processing	(1-2)1
TE	212	Fiber Science	(3-1)3
		Total hours	(16-4½)17

JUNIOR YEAR

First Semester

MA	355	Digital Computer Programming	(2-2)2
MA	383	Statistical Methods	(3-0)3
ME	311	Applied Mechanics III	(3-0)3
ME	341	Thermodynamics	(3-0)3
*ME	377	Elements of Materials Science	(2-0)2
TE	363	Textile Systems I	(3-1)3
		General Elective	(3-0)3
		Total hours	(19-3)19

*ROTC students will substitute AS 301.

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
ME	314	Mechanical Engineering Laboratory I	(0-3)1
*ME	342	Thermodynamics	(3-0)3
ME	382	Fluid Mechanics	(3-0)3
TE	364	Textile Systems II	(3-2)3
TE	366	Textile Systems III	(2-1)2
		General Elective	(3-0)3
		Total hours	(17-8)19

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory II	(0-3)1
ME	421	Machine Design	(2-3)3
ME	443	Heat Transfer	(3-0)3
ME	495	Electromechanical Engineering	(3-2)4
TE	367	Textile Systems IV	(2-1)2
TE	483	Engineering Design of Textile Structures	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-9)19

Second Semester

ME	416	Mechanical Engineering Laboratory III	(0-3)1
TE	472	Textile Evaluation	(2-3)3
TE	482	Application of Scientific Methods to Textile Processes	(3-0)3
TE	484	Engineering Design of Textile Structures	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective (Textile)	3
		Total credit hours	19

TEXTILE TECHNOLOGY

This course of study is designed to equip its students with a well-rounded understanding of the theory and principles relating to the processing of textile materials. At the same time it provides the scientific basis necessary to understand and apply this technological knowledge. Basic purpose of the program is to prepare students to become competent textile technologists for eventual supervisory, administrative, or executive positions within the industry and its allied fields. To achieve this end, a comprehensive course covers the basic theory, principles, and applications of the major phases of textile manufacture utilizing all the common fibers, both natural and man-made, and all fabricating processes.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	203	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Applied Mechanics I	(3-0)3
PH	205	Physics	(4-2)4
		Total hours	(17-2)17

Second Semester

EC	202	Economics II	(3-0)3
EE	204	Introductory Electronics	(3-1½)4
MA	206	Differential Equations	(3-0)3
ME	214	Applied Mechanics II	(3-0)3
ME	262	Machine Tool Laboratory	(1-2)1
TE	212	Fiber Science	(3-1)3
		Total hours	(16-4½)17

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	341	Thermodynamics	(3-0)3
*ME	377	Elements of Materials Science	(2-0)2
ME	381	Fluid Mechanics	(3-0)3
TE	363	Textile Systems I	(3-1)3
		General Elective	(3-0)3
		Total hours	(17-1)17

*ROTC students will substitute AS 301.

Second Semester

EE	324	Electrical Energy Conversion	(3-2)4
MA	356	Digital Computer Programming	(2-2)2
TE	322	Yarn Technology	(2-2)3
TE	364	Textile Systems II	(3-2)3
		Two General Electives	(6-0)6
		*Technical Elective (Textile)	3
		Total credit hours	21

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

IM	483	Statistical Quality Control	(3-0)3
*ME	421	Machine Design	(2-3)3
TE	435	Fabric Technology	(3-2)4
TE	457	Technology of Finishing	(2-0)2
TE	459	Textile Drying—Theory and Practice	(1-0)1
TE	483	Engineering Design of Textile Structures	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-5)19

*ROTC students will substitute AS 401.

Second Semester

ME	444	Heat Transfer	(3-0)3
TE	458	Technology of Finishing	(1-2)2
TE	472	Textile Evaluation	(2-3)3
TE	474	Instrumentation for Textiles	(2-2)3
TE	484	Engineering Design of Textile Structures	(3-0)3
		*Technical Elective (Textile)	3
		Total credit hours	17

*ROTC students will substitute AS 402.

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Aerospace Studies	ME	Mechanical Engineering
BA	Business Administration	NU	Nuclear Science and Engineering
BI	Biology	PA	Paper
CH	Chemistry	PH	Physics
CHE	Chemical Engineering	PL	Plastics
EC	Economics	SS	Social Sciences
EE	Electrical Engineering	TC	Textile Chemistry
IM	Industrial Management	TE	Textiles
LL	Languages and Literature		
MA	Mathematics		

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are restricted to graduate students. An asterisk following the subject number, e.g., PH 411-412*, indicates a subject which, although it is primarily for undergraduates, may ordinarily be taken for full graduate credit.

Odd numbers designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Hyphenated numbers indicate subjects continuing throughout the year.

Prequisites are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

AFROTC Drill Team Ceremony

Soccer Team

AEOROSPACE STUDIES

AS 101-102 World Military Systems I and II (1-1) (1-1)2

An introductory course exploring the causes of the present world conflict, the role and relationship of military power to the conflict, and the responsibility of an Air Force officer. The course begins with a discussion of the factors from which differing political philosophies have evolved. It continues with a tridimensional analysis of the three prime political philosphies which have guided segments of society in the twentieth century. This is followed by a discussion of the means that nations develop to pursue their objectives and how they confront each other in the use of these means. The course then treats individual military systems, with emphasis upon the U.S. Department of Defense and the U.S. Air Force.

AS 201-202 World Military Systems III and IV (1-1) (1-1)2

Continued study of world military forces and the political-military issues surrounding the existence of these forces. This includes a study of the United States Army and the United States Navy and their doctrines, missions, and employment concepts; a study of the military forces of NATO, CENTO, and SEATO and their roles in free world security; and an investigation of the military forces of the USSR, the Soviet satellite armies, and the Chinese Communist Army. An analysis of the trends and implications of world military power.

AS 301-302 Growth and Development of Aerospace Power I and II (3-1) (3-1)6

A survey course about the nature of war; development of airpower in the United States; mission and organization of the Defense Department; Air Force concepts, doctrine, and employment; astronautics and space operations; and the future development of aerospace power, including United States space programs, vehicles, systems, and problems in space exploration. The above areas are studied through the media of briefings, discussions, debates, and written reports by the student to improve his communicative skills.

AS 401-402 The Professional Officer I and II (3-1) (3-1)6

A study of professionalism, leadership, and management, including the meaning of professionalism; professional responsibilities; the military justice system; leadership theory, functions, and practices; management principles and functions; problem solving; and management tools, practices, and controls. The above areas are studied through the media of discussions, briefings, and written reports by the student to improve his ability to communicate.

BUSINESS ADMINISTRATION

BA 141-142 — Accounting I and II — (3-0) (3-0)6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 241-242 — Accounting III and IV — (3-0) (3-0)6
[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 — Marketing Principles — (3-0)3
[EC 202]

Analysis of modern methods of marketing and merchandising as they are related to consumer, producer, and middleman.

BA 322 — Marketing Problems — (3-0)3
[BA 321]

[For students majoring in Business Administration]
An analytic approach to marketing strategy in relation to the problems of organization, coordination, and control. Price policies, the government's role in marketing, and physical distribution.

BA 324 — Industrial Marketing — (3-0)3
[BA 321]

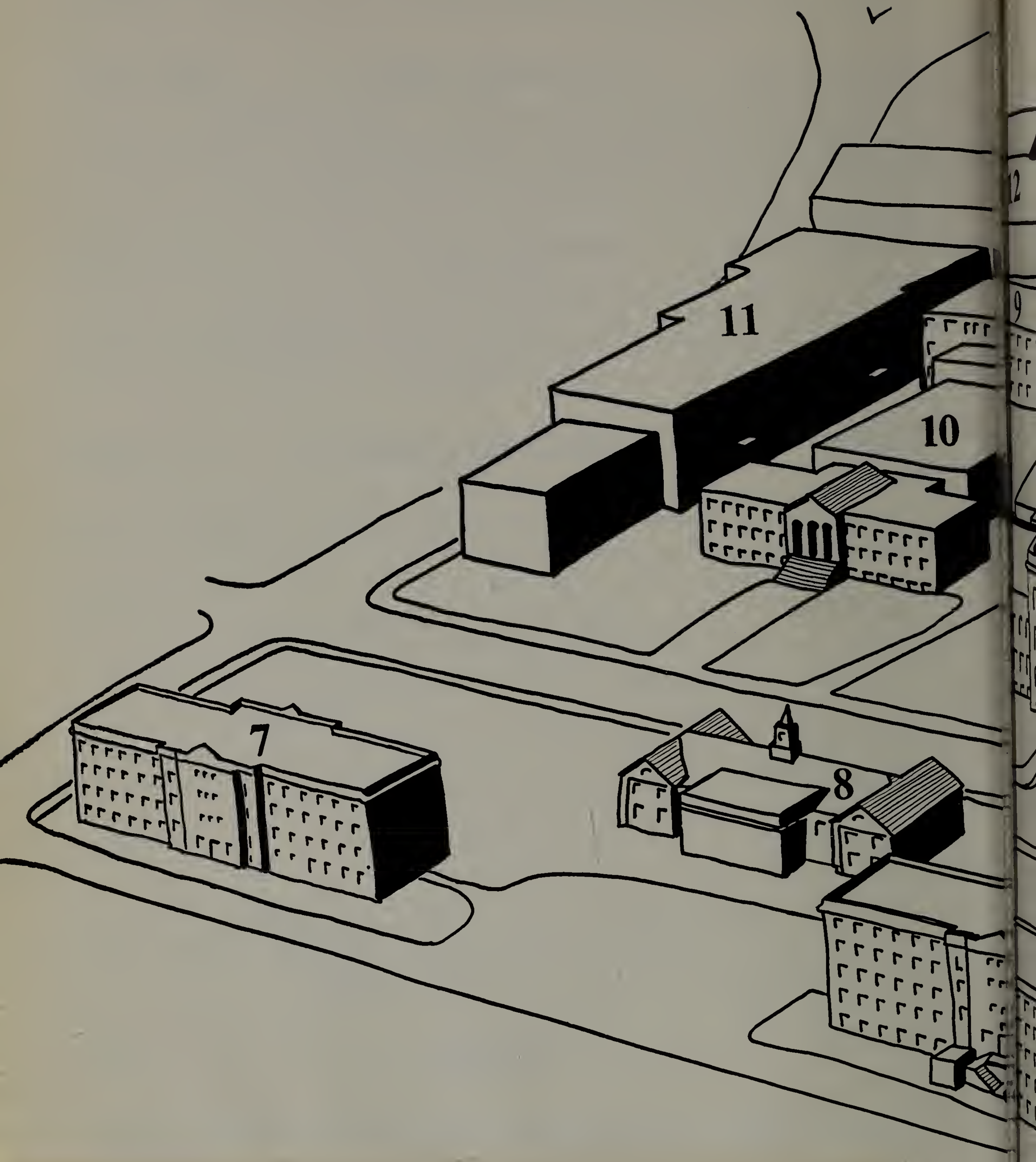
[For students majoring in Industrial Management]
Problems of marketing industrial goods. Distribution channels, price policies, product line planning, and marketing programs.

BA 325 — Advertising — (3-0)3
[BA 321]

The relation of advertising to modern business organization and its place in marketing and distribution.

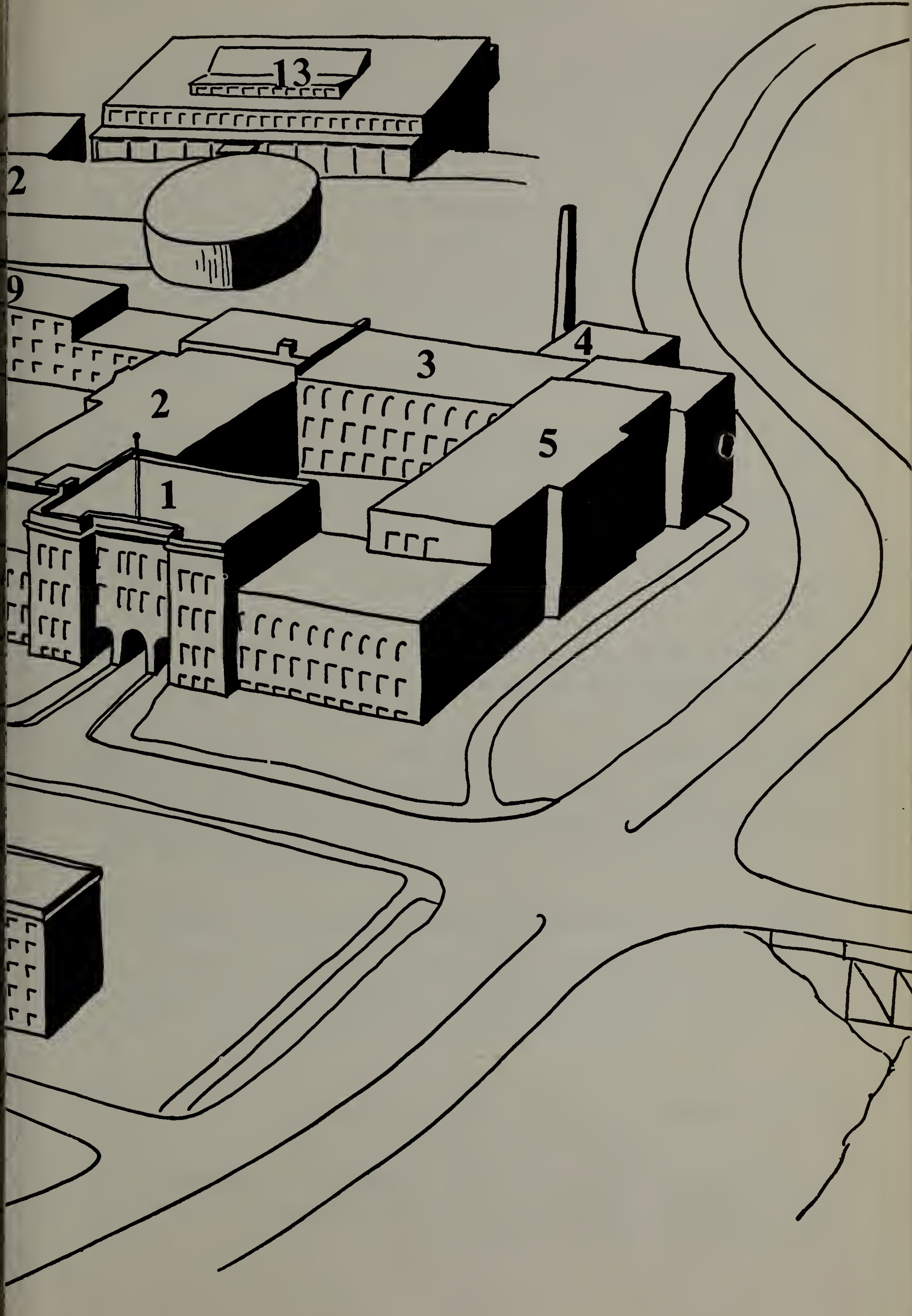
BA 331 — Corporation Finance — (3-0)3
[BA 142, EC 202]

Financial aspects of the single proprietorship, partnership, and corporation. The financial function, sources of funds, financial statements, capitalization, and legal aspects of the corporation.



LOWELL TECHNOLOGICAL INSTITUTE
LOWELL, MASSACHUSETTS

1 — Southwick Hall
2 — Kitson Hall
3 — Falmouth Street Building
4 — Power Plant
5 — Pasteur Hall
6 — Smith Hall
7 — Eames Hall
8 — Alumni Memorial Library
9 — Olney Hall
10 — Cumnock Hall
11 — New Classroom-Laboratory Building
12 — Nuclear Center (under construction)
13 — Proposed Gymnasium



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BA 332 **Money and Banking** **(3-0)3**
[EC 201]

The role of money and monetary policy in the United States. The bank ing structure, the Federal Reserve System, other financial institutes, and international monetary systems.

BA 334 **Investments** **(3-0)3**
[BA 331]

The organization and operation of stock and bond markets, security speculation, brokerage houses, security price behavior, and exchange regulations.

BA 341 or 342 **Accounting V and VI** **(3-0) (3-0)6**
[BA 242]

Advanced accounting, comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

BA 344 **Cost Accounting** **(2-2)3**
[BA 142]

Job lot, process, and standard cost systems, including joint and by-product problems, and the managerial uses of cost data.

BA 361 or 362 **Business Law** **(3-0)3**

The principles of commercial law, including contracts, agency, sales, partnerships, corporations, negotiable instruments, bailments and carriers, insurance, personal property, real property, suretyship and guarantees, and bankruptcy.

BA 371-372 **Production Management I and II** **(3-0) (3-0)6**

The internal organization and productive process of the manufacturer, including the management functions of planning, directing, and administration in relation to production. Plant layout, materials handling, inventory control, quality control, and time and motion study systems.

BA 401 or 402 **International Business Operations** **(3-0)3**
[EC 202]

The distinctive features of international commerce, including government policies, multinational corporate problems, foreign exchange, tax problems, and special licensing and agency arrangements.

BA 403 or 404 Electronic Data Processing (3-0)3

The role of digital computers in the solution of management problems. The preparation and solution of sample problems on the Institute's IBM 1620 installation.

BA 421 or 422 Procurement (3-0)3
[BA 324]

Purchasing procedure, quality control, inventory control, source selection, forward buying, and speculation, as applied to the industrial enterprise.

BA 423 or 424 Marketing Management (3-0)3
[BA 321]

Problems of marketing, especially from the point of view of the formulation of business policy.

BA 426 Sales Management (3-0)3
[BA 321]

Management of the selling function in its broad aspect. Sales organization, compensation, selection, training, and supervision. Market research, product packaging and development, and distribution policies.

BA 431 or 432 Financial Management (3-0)3
[BA 331]

The finance function in business, funds procurement and their effective utilization, and financial budgets.

BA 441 or 442 Auditing (3-0)3
[BA 342]

Duties and responsibilities of the auditor, kinds of audits, programs of audit, and auditor statements and reports.

BA 443 or 444 Accounting Systems (3-0)3
[BA 342]

Principles of system design; internal control, division of labor, routing of business papers, and procedural practices; systems modifications; and relationship of theory and practice of accounting to systems.

BA 445 or 446 Tax Accounting (3-0)3
[BA 342]

Tax problems of partnerships, corporations, reorganizations, personal holding companies, trusts, gifts, and estates. Problems and interpretations of the internal revenue code and regulations of both the Federal and State agencies.

BA 451 **Personnel Management** **(3-0)3**

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as employee health and safety, welfare and education, and wage and salary administration.

BA 452 **Industrial Relations** **(3-0)3**
[BA 451]

Human interaction and group behavior in organized industrial settings. Interpersonal and intergroup conflict, motivation, and leadership. Case problems.

BA 481 or 482 **Insurance** **(3-0)3**

Theory of risk, physical and moral hazards, types of insurance carriers, and basic features of each of the principal kinds of insurance.

BA 491 or 492 **Transportation** **(3-0)3**

Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies of the United States.

BA 501 or 502 **Research Seminar** **(3-0)3**
[Permission of Department Head]

Designed to give the better Business Administration student an opportunity under the direction of a faculty member to do research in, and report on, an area of special interest.

BIOLOGY

BI 101-102 **Introductory Biology** **(3-0) (3-0)6**

A series of lectures and demonstrations designed to introduce the student to the principles and characteristics of living forms, with special reference to the cell and its metabolism and to the anatomy, physiology, and evolution of the major groups of the animal kingdom.

CHEMISTRY

CH 101-102 **Introduction to Chemical Principles** **(4-2) (4-2)8**
An introduction to the structure and reactivity of chemical species based on the periodic properties of the elements. Physical aspects of chemical theory are stressed and correlated.

CH 103-104 **Introductory Chemistry** **(3-0) (3-0)6**

[Not open to chemistry majors]

Selected topics dealing with the important chemical principles, inorganic and organic chemistry, and the major industrial applications.

CH 201-202 **Organic Chemistry** **(3-3) (3-3)8**

[CH 102]

The classification, nomenclature, structure, mechanism of reaction, and behavior in bulk of important kinds of organic species. The laboratory work illustrates the experimental techniques which can be used to react, purify, characterize, and identify organic substances.

CH 205 **Qualitative Analysis** **(3-0)3**

[CH 102]

[Primarily for students not majoring in chemistry]

A lecture course dealing with the physical chemistry of aqueous electrolytic solutions. The nature and behavior of solutes and solutions; reaction rate theory and its relation to solubility, proton transfer, and other types of equilibria; and application of the above principles to problems of separation and identification.

CH 207 **Electrolytic Solutions** **(2-3)3**

[CH 102]

[Primarily for students majoring in chemistry]

An introduction to the physical chemistry of electrolytic solutions, with emphasis on aqueous systems. Reactions involving ions, i.e., proton transfer, precipitation, complexation, and oxidation-reduction, studied rigorously both from a kinetic and an equilibrium approach. Extensive drill in calculations involving equilibrium constants of various types. The laboratory serves to investigate quantitatively some of the phenomena discussed in lectures.

CH 208 **Inorganic Chemistry** **(3-0)3**

The chemical behavior, electronic and geometric structures, methods of preparation, reactions, and nomenclature of some of the more common elements and their compounds as well as some of the better-known transition and inner-transition elements. The laboratory deals with the preparation and study of some of the more interesting compounds.

CH 209 **Analytical Techniques** **(1-3)2**

[CH 102]

[Primarily for students majoring in chemistry]

The fundamentals of analytical techniques, including basic gravimetric and volumetric measurements and their calculations.

CH 210 **Analytical Chemistry** **(3-6)5**

[CH 207 and CH 209]

[Primarily for students majoring in chemistry]

The fundamental principles of analytical chemistry, both qualitative and quantitative, including the separation, identification, and quantitative measurement of substances through chemical methods, chromatography, ion exchange, microscopy, fluorometry, and spectroscopy.

CH 212 **Quantitative Analysis** **(3-4)4**

[CH 102]

[Primarily for students not majoring in chemistry]

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric and volumetric analysis, including some coverage of industrial applications.

CH 321 **Organic Chemistry Laboratory II** **(0-6)2**

[CH 202]

A continuation of the laboratory portion of CH 202 involving additional laboratory work in synthetic organic chemistry.

CH 331-332 **Physical Chemistry** **(3-3) (3-3)8**

[CH 102, MA 205, PH 205]

The formulation and development of the mathematical and mechanical models of theoretical chemistry and their uses in the solution of the practical problems of chemistry and chemical engineering. Topics included are atomic and molecular structure, states of matter, thermodynamics, thermochemistry solutions, electrochemistry, colloids, chemical equilibrium, kinetics, and photochemistry.

CH 334 **Colloid Chemistry** **(3-0)3**

[CH 331 or equivalent]

Theoretical properties of the colloid system. Interfacial phenomena, particle kinetics, electrical properties, and viscosity characteristics are studied. The character of lyophobic and lyophilic sols, gels, and emulsions is developed from the above properties.

CH 342 **Organic Qualitative Analysis** **(1-6)3**

[CH 202; CH 205 or 206]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 403-404 Chemistry of High Polymers (3-4) (3-4)8
[CH 202, CH 332]

The physical and organic chemistry of monomers and polymers, including a consideration of non-bonding forces, spectroscopic methods of structure determination, structure and property correlations, fractionation, thermodynamics, and methods of molecular weight determination for polymers in solution; the kinetics of condensation and addition polymerization as applied to polymers and copolymers, mechanism of free radical and ionic polymerization, stereospecific polymers, the chemistry of the more common polymer systems, and preparation of their corresponding monomers.

CH 407-408 Advanced Studies In Chemistry Credits to be arranged
[Permission of the Chairman of the Chemistry Division and the instructor]

Advanced work in analytical, organic, inorganic, physical, or textile chemistry, including literature survey, laboratory work, and reports.

CH 411 Advanced Analytical Chemistry (2-4)3
[CH 211 or 212; CH 332]

Advanced analytical techniques based on physical-chemical principles and utilizing instrumental methods wherever applicable. The analytical use of complexes, radiant energy methods, electrochemistry, chromatography, polarography, analytical applications of radioisotopes, and physical methods of separation.

CH 423-424* Advanced Organic Chemistry (3-0) (3-0)6
[CH 202]

Extension of first-year organic chemistry to include additional classes of compounds and special topics. Emphasis is placed on synthetic methods, including the mechanism, scope, and limitations of the important name reactions in the field of synthetic organic chemistry.

CH 431-432* Advanced Physical Chemistry (3-0) (3-0)6
[CH 332 or equivalent]

An extension of introductory physical chemistry for undergraduate majors and first-year graduate students in chemistry and related fields, with emphasis on classical and statistical thermodynamics as they apply to the various chemical phenomena.

CH 443-444* **Advanced Inorganic Chemistry** **(3-0) (3-0)6**
[CH 332]

A treatment of the structure and reactions of the inorganic elements and their compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics and the theory of the chemical bond, spectroscopy, inorganic stereochemistry, crystal field theory, reactions in nonaqueous solvents, coordination chemistry, and atomic structure, including the structure of the atomic nucleus.

CH 481* **Radiochemistry** **(3-3)4**
[CH 332]

Fundamentals of radiochemistry, including radioactivity, atomic nuclei, nuclear reactions, reactors, and radiation detection and measurement with emphasis on the use of radioactive materials in chemical applications. Designed primarily for majors in chemistry and in allied fields.

CH 483 or 484 **Nuclear Chemistry and Radiochemistry** **(3-3)4**
[CH 102]

A review of chemical principles as applied to radiochemistry, including coverage of such topics as radioactivity, nuclear reactors, radiation chemistry, use of tracers in chemical application, and separation and study of fission products.

CH 501 **Interpretation of Data** **(3-0)3**

Mathematical methods of analyzing, plotting, and interpreting experimental data. Lectures and exercises.

CH 502 **Absorption Spectrophotometry and Color Measurement** **(2-3)3**

Theory and application of absorption spectrophotometry to the qualitative and quantitative analyses of chemical substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges, including theories of color, vision, and subjective color evaluation.

CH 503-504 **Chemistry of High Polymers** **(3-0) (3-0)6**
[CH 202, CH 332]

An introduction to the physical and organic chemistry of high polymers for graduate students. Similar to CH 403-404 but with additional assigned reading.

CH 505-506 **Techniques of Polymer Chemistry** **(0-4) (0-4)2**

A laboratory subject to be taken concurrently with CH 503-504 and designed to acquaint a graduate student majoring in Polymer Science with the techniques used in the preparation, characterization, and investigation of macromolecular substances.

CH 507-508 Chemistry Seminar (1-0) (1-0)2

CH 512 Physical Chemistry of Surface-Active Agents (3-0)3

A series of lectures on the physicochemical principles involved in the use of surface-active agents. The surface and bulk properties of the agents are studied and related to the over-all technical properties and uses.

CH 513 Chemical Applications of Spectroscopy and Spectrophotometry (3-0)3

Theory, limitations, and applications of various types of spectroscopy to chemical research. Visible and ultraviolet, infrared, microwave, nuclear magnetic, and electron paramagnetic resonance spectroscopy. Emphasis is given to the interpretation of spectra, with some importance placed on analytical applications.

CH 514 Physicochemical Methods (2-0)2

An outline of some of the more important physical methods of investigation and their applications to chemical research, including refractometry, polarimetry, microscopy, and chromatography (ion-exchange, adsorption, and gas).

CH 521-522 Physical Organic Chemistry (3-0) (3-0)6

[CH 424, CH 444]

Modern concepts of molecular structure developed and related to the physical and chemical properties of organic compounds. Polarization effects and reaction mechanisms considered in detail.

CH 527-528 Stereochemistry (3-0) (3-0)6

The fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.

Offered in alternate years; offered in 1965-66.

CH 531-532 Chemical Thermodynamics (3-0) (3-0)6

[CH 539 or equivalent]

An advanced subject in chemical thermodynamics, with emphasis on the recent mathematical developments in the description of chemical systems and with attention given to current experimental methods of obtaining thermodynamic data. The chemical and physical scientific literature is used extensively.

CH 533 **Statistical Mechanics for Chemists** **(3-0)3**

[CH 539 or equivalent]

A continuation of the introductory statistical mechanics presented in CH 539. Current theories on such topics as configuration of polymer molecules, rubber elasticity, and solution structure, as well as principles of classical statistical mechanics.

CH 534 **Quantum Mechanics for Chemists** **(3-0)3**

[CH 539 or equivalent]

A continuation of the introduction to quantum mechanics in CH 539. Current theories on such topics as quantum mechanical treatment of crystalline solids, imperfect gases and liquids, and electromagnetic susceptibilities.

CH 535-536 **Advanced Topics in Physical Chemistry** **(3-0) (3-0)6**

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 538 **Rheology** **(3-0)3**

The general principles of the deformation and flow of matter under stresses studied qualitatively and quantitatively. Hookean and non-Hookean elasticity and Newtonian and non-Newtonian flow related to the properties of materials, especially in the field of high polymers.

CH 539 **Theoretical Chemistry** **(3-0)3**

[CH 443-444 or equivalent]

The formal and group theoretical aspects of quantum chemistry particularly as they apply to molecular structure and reactivity.

CH 540 **Chemical Kinetics** **(3-0)3**

[CH 432 or equivalent]

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanism, collision theory, and absolute rate theory.

CH 541-542 **Graduate Thesis** **Credits to be arranged**

An independent investigation of a problem by the student in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

CH 551-552 Physical Chemistry of Macromolecules (3-0) (3-0)6
[CH 404, CH 432]

An advanced treatment of the physical chemistry of macromolecules, including methods available for molecular structure determination. Consideration of the thermodynamic and statistical approaches to the theory of high-polymer solutions, with particular emphasis on molecular weight dependencies and a study of the kinetics of polymerization and depolymerization.

Offered in alternate years; not offered in 1965-66.

CH 553 Organic Chemistry of Macromolecules (3-0)3
[CH 403, CH 424]

An advanced study in polymer science concerned with modern theoretical concepts and including mechanisms of formation and degradation of macromolecules.

Offered in alternate years; not offered in 1965-66.

CH 554 Stereochemistry of Macromolecules (3-0)3
[CH 404, CH 424]

Stereochemical factors affecting the formation and properties of macromolecules.

Offered in alternate years; not offered in 1965-66.

CH 555 Polymer Physics (3-0)3

A general treatment of the physical behavior of high-polymer systems. Lectures cover microscopic structure, including the structure of polymer molecules, intermolecular forces, first- and second-order transitions and macroscopic behavior including rheology and mechanical behavior, the kinetic theory of rubber elasticity, electrical, optical, and thermal properties. Comparisons are made with other classes of materials from time to time to emphasize the unique properties of high polymers.

Offered in alternate years; offered in 1965-66.

CH 556 Physical Chemistry of Surfaces (3-0)3

Energetics of surfaces, adsorption, monolayers and films, electrical aspects of surface chemistry, and reactions at interfaces.

CH 561-562 Advanced Organic Synthesis (3-0) (3-0)6
[CH 423-424 or equivalent]

The application of known organic reactions to the synthesis of chemical species in such fields as the terpenes, steroids, alkaloids, antibiotics, and selected heterocyclic derivatives.

Offered in alternate years; not offered in 1965-66.

CH 564 **Organic Qualitative Analysis** **(1-6)3**

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 **Metal-Organic Compounds** **(3-0)3**

The chemistry of the important classes of metal-organic compounds, including bis-arene derivatives, as well as the organosilicon, organoboron, and organophosphorus classes.

Offered in alternate years; offered in 1965-66.

CH 566 **Heterocyclic Chemistry** **(3-0)3**

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years; offered in 1965-66.

CHEMICAL ENGINEERING

CHE 203 **Introduction to Chemical Engineering** **(1-0)1**

General discussion of the chemical industry and the part played by the science and engineering disciplines in chemical engineering; scope of the industry and its economic structure; and an introduction to chemical engineering principles.

CHE 204 **Industrial Stoichiometry** **(3-0)3**

[CH 205; CH 212 taken concurrently]

Material balances and energy balances, including phase separation and thermochemistry, and theor application to chemical engineering processes. Development of unsteady-state concepts.

CHE 303 **Chemical Engineering I** **(3-0)3**

[CHE 204, MA 205]

Unit operations of fluid flow, mixing, materials handling, size reduction and separation, and filtration.

CHE 304 **Chemical Engineering II** **(3-0)3**

[CHE 303, MA 206]

Unit operations of heat transfer, evaporation, and mass transfer.

CHE 312 **Chemical Engineering Thermodynamics** **(3-0)3**

[ME 341]

Application of the first and second laws of thermodynamics to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature; fugacity and activity; state properties; homogeneous and heterogeneous equilibria; and electrochemical effects.

CHE 405 **Chemical Engineering III** **(3-0)3**

Unit operations of gas absorption, distillation and extraction, leaching and crystallization, air/water contact operations, and drying.

CHE 407 **Industrial Chemistry I** **(3-0)3**

[CH 332, CH 204; CHE 405 taken concurrently]

A qualitative and quantitative study of selected chemical engineering processes and the analysis of material and heat balances, equilibria, rates of reaction, flow sheets, and economic factors. Reports and plant visits.

CHE 408 **Industrial Chemistry II** **(3-0)3**

[CHE 407]

Detailed study of the fertilizer, plastics, and petroleum industries; organic chemicals manufacture; manufacture of ferrous and non-ferrous metals; and the electrochemical industry. Reports and plant visits.

CHE 410 **Economic Balance and Plant Design** **(3-0)3**

[CHE 405]

Economic principles applied to the evaluation and optimization of various chemical engineering processes. Several minor projects and a major design problem requiring written reports provide practical application of the various engineering and economic principles.

CHE 411-412 **Chemical Engineering Laboratory** **(0-6) (0-6)4**

[CHE 405 taken concurrently]

Experimental studies and projects involving various unit operations. Both individual and group projects. Written and oral reports are required.

CHE 501-502 **Distillation** **(3-0) (3-0)6**

[CHE 405, CHE 408]

Review of principles of distillation and phase separation and their application to multicomponent distillation. Design of columns, analysis of specific systems, and plate design.

CHE 503-504 **Absorption and Extraction** **(3-0) (3-0)6**

[CHE 405, CHE 408]

Principles of separation; phase diagrams and multicomponent mixtures; and mathematical and graphical solutions to mass transfer problems.

CHE 505 **Colloid Chemistry for Chemical Engineers** **(3-0)3**

Colloid principles applied to chemical engineering problems; zeta potential; specific problems involving surface chemistry and physics; and the mathematics of colloidal systems.

CHE 507 Corrosion and Electrochemical Principles (3-0)3

Electrochemical principles and physical chemistry relating to the corrosion of metals. Materials of construction and designs based on these principles.

CHE 509 Mathematics for Chemical Engineers (3-0)3

[MA 206, CHE 405]

Application of mathematics to chemical engineering problems; unsteady-state equations and problems; and analysis of specific real problems.

CHE 511 or 512 Structure and Property of Matter (3-0)3

Fundamental properties of matter as they relate to chemical engineering problems. Materials of construction. Rheological properties of polymeric materials and their application to chemical engineering.

CHE 513 Advanced Economic Balance and Plant Design (3-0)3

[CHE 410 or equivalent]

Detailed study of several processes from the standpoint of optimization and economics of design. Group design of a specific chemical plant. Use of computers for solution of design problems.

CHE 523 or 524 Advanced Industrial Chemistry (3-0)3

[CHE 408 or equivalent]

The economics and interrelationships of the chemical industry. Detailed study of entire operations of a few important chemical and petrochemical processes.

CHE 528 or 529 Heat Transfer (3-0)3

Review of principles of energy transport. Specific problems in convection and radiant heat transfer. Mathematical treatment of unsteady-state heat transfer.

ECONOMICS

EC 201 Economics I (3-0)3

The foundations and nature of economic principles. National income, money and banking, and monetary and fiscal policy.

EC 202 Economics II (3-0)3

[EC 201]

Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 211-212 Economic Statistics I and II (3-0) (3-0)6

Basic concepts of statistical methods. Topics covered include measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 Economic Development of the United States (3-0)3

The background of the present economic system and an intensive study of the influence of science and technology upon our economic development.

EC 302 Labor Economics (3-0)3

[EC 202]

The effect of the operation of American capitalism upon the position of labor. Analysis of the rise of union organization and the factors in its growth. Consideration of trends in the labor forces, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 Microeconomic Theory (3-0)3

[EC 202]

An advanced examination of price and production theory. The theory of the household and the firm.

EC 304 Macroeconomic Theory (3-0)3

[EC 202]

An analysis of Keynesian and post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 401 or 402 Government and Business (3-0)3

[EC 202]

An examination of federal, local, and state controls on business activity, with emphasis on the economic interpretation of the various statutes and court decisions involving business.

EC 403 or 404 International Trade Theory (3-0)3

[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 412 Managerial Economics (3-0)3

[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis, and competitive action.

Chemistry Laboratory

IBM 1620 Digital Computer Laboratory

EC 414 **Engineering Economy** **(3-0)3**

[EC 202, or permission of instructor]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

ELECTRICAL ENGINEERING

EE 201-202 **Introductory Circuit Theory** **(3-0) (3-0)6**

[MA 108 and PH 104; MA 205 and 206 taken concurrently]

An introduction to the study of the mathematical and physical aspects of electric circuits in which radiation in the form of electromagnetic waves does not play a major role. Kirchhoff's laws, Thevenin's theorem, reciprocity of simple circuits, vector diagrams, vector algebra, sinusoidal steady-state behavior of simple circuits, transients in alternating-current circuits, and coupled circuits.

EE 203 **Fundamentals of Electricity** **(3-0)3**

[PH 104; MA 205 taken concurrently]

An introduction to electric circuits for students not majoring in Electrical Engineering but who have a background in basic principles of electricity and magnetism. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state a.c. circuits, two-terminal networks, and two-terminal-pair networks.

EE 204 **Introductory Electronics** **(3-1½)4**

[EE 203, MA 205]

A background subject in electronics for students not majoring in Electrical Engineering, presenting the properties and uses of vacuum tube and semiconductor devices.

EE 205 **Basic Electrical Engineering Laboratory** **(0-3)1**

[EE 201 taken concurrently]

Experimental work designed to acquaint the student with electrical instruments and the techniques of electrical measurements and to provide experimental verification of the behavior of passive electrical circuits.

EE 301-302 **Electronic Devices/Models** **(3-0) (3-0)6**

[EE 202, MA 206]

Basic concepts, techniques, and methods of analysis of electronic devices, with particular emphasis on the break-point method, piecewise linearization, and active circuit theory. Diode operation, rectification, amplification, and RC/RL wave-shaping. Single-stage, multistage, power, and tuned amplifiers discussed with consideration of gain, band-width, and frequency response.

EE 303-304 — Electromagnetics — (3-0) (3-0)6

[EE 202, MA 206]

Electricity and magnetism presented from the field theory point of view, using vector analysis and Maxwell's equations. The static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials, time-changing electric and magnetic fields, magnetic induction, electromagnetic waves and energy flow, and boundary value problems.

EE 307-308 — Network Analysis — (3-0) (3-0)6

[EE 202, MA 206]

Continuation of discussions begun in EE 201-202, with emphasis on frequency domain analysis. Mutual inductance, coupled circuits, and transformers; open-circuit and short-circuit natural frequencies and impedance by inspection techniques; complete solution of linear passive networks; power and energy associated with arbitrary excitation functions; Fourier and Laplace transformations and a comparison of network analysis by these methods with the classical differential equation approach; numerical evaluation methods using impulse train techniques; and convolution in the time and frequency domain. Selected topics from the theory of determinants, matrices, linear transformations and quadratic forms and functions of a complex variable emphasizing the basic aspects for analysis problems. A brief introduction to synthesis.

EE 309-310 — Electronic Devices Laboratory — (0-3)1

[EE 301-302 and EE 307-308 taken concurrently]

An intermediate laboratory course in which the experiments are designed to stimulate an appreciation for and a realization of the limitations of basic electronic equipment. The experiments are closely coordinated with the allied concurrent courses and provide experimental verification of the principles of electronic devices and circuits.

EE 313 or 314 — Digital Computers— Applications and Programming — (2-2)3

The physical principles and instrumentation of digital computers and their application to problems in science and engineering. Programming methods and techniques.

EE 323 or 324 — Electrical Energy Conversion — (3-2)4

[EE 203, MA 205]

The generation, control, utilization, and conversion of electrical energy, with special attention given to the construction, characteristics, and operation of direct-current and alternating-current machinery and rectifiers.

EE 351 or 352 — Industrial Electronics — (3-0)3

[MA 108, PH 104]

[Not open to students majoring in Electrical Engineering, Mechanical Engineering, Physics, or Textile Engineering]

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum- and gaseous-tube characteristics and of circuits containing such tubes for the purpose of rectification, amplifications and oscillation; and industrial photoelectric and time delay relays.

EE 401-402* — Feedback Control Systems and Their Components — (3-0) (3-0)6

[EE 202, MA 311]

The various methods of analysis and design of feedback control systems, including the time-domain, frequency-domain, and root-locus approaches. Some coverage of control system components is included.

EE 403-404 — Microwave Electronics — (3-0) (3-0)6

[EE 304, MA 311]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, generation and focusing of high-current electron beams with electric and magnetic fields, electron optics, velocity modulation, space charge wave propagation and traveling wave interaction with electron beams with application to microwave amplifiers and oscillators, and antennas.

EE 405-406* — Communication Electronics — (3-0) (3-0)6

[EE 302, MA 311]

Theory and application of thermionic tubes and transistors in amplifiers, oscillators, modulators, and detectors operating class A and in the switching mode. Principles of television and radar communication. Noise in electron devices and circuits.

EE 409-410 — Applied Electronics Laboratory — (0-4) (0-4)4

[EE 310]

The purpose of this subject is to give the student an experimental familiarity with the nature, application, and performance of various electronic devices. Emphasis is given to methods of electrical measurement and the preparation of good technical reports.

EE 411-412 — Logical Design of Digital Computers — (3-0) (3-0)6

[EE 302]

Foundations for the complete design of digital computer subsystems, such as arithmetic unit, computer memory, control, and input-output equipment with emphasis on basic circuitry as well as the logical tools: flip-flops, shift-register, logical gates, and magnetic core memories. Boolean algebra, systems synthesis, coding, and error detection.

EE 425-426* **Wave Shaping and Generation** **(3-0) (3-0)6**
[EE 302, MA 311]

Principles and methods of wave shaping and wave generation using active and passive elements. Timing, switching, memory devices, oscillations, and wave shaping. Free use is made of piecewise-linear approximation, the break-point method, and/or the assumed diode state in conjunction with linear network theory. Particular emphasis is given to model representation and its analysis.

EE 427-428 **Semiconductor Electronics** **(3-4) (3-4)10**
[EE 302, EE 308, MA 311]

Properties of semiconductor devices; a study of transistors as active network elements, based on two-part theory in matrix presentation; transistor devices analyzed in the periodic steady state and the transient state by transform methods and other methods; and solution by modern methods of problems on linear and non-linear semiconductor devices. Practical experience in transistors, tunnel diodes, and similar devices is gained from an extensive laboratory course.

EE 429-430 **Network Synthesis** **(3-0) (3-0)6**
[EE 308, MA 311]

A review of methods of analysis useful in the study of signals, systems, and their response; impedance and admittance properties relating the frequency and time domain aspects of physical circuit behavior; linear passive network theory, emphasizing the synthesis aspects; fundamental works of Foster, Cauer, Brune, Darlington, and Guillemin applied to design of networks having a prescribed driving-point and transfer characteristics; synthesis of coupling networks for prescribed transfer characteristics, including RC, RLC, and minimum-phase and nonminimum-phase types; real part sufficiency and related topics; and Fourier, Laplace, and Hilbert transforms.

EE 431-432 **Special Topics in Electronics** **(3-0) (3-0)6**

An analytical consideration of special topics of importance in the field of electronics.

EE 433-434 **Electro-Optional Analogues** **(3-0) (3-0)6**
[EE 302, EE 308, MA 311]

A review of linear system analysis, including Fourier analysis, as applied to the analysis of linear electrical and optical systems, with emphasis on the similarities of the two classes of systems.

EE 501-502 **Applied Statistics** **(3-0) (3-0)6**

Consideration of electromagnetic waves in physical media by statistical analysis methods.

EE 503-504 Solid-State Physical Electronics (3-0) (3-0)6

A physical interpretation of the properties of materials in terms of their dielectric constant, magnetic permeability, and electrical conductivity; dielectric, ferroelectric, and piezoelectric materials; diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic materials; metals, semiconductors, and insulators; and applications to electrical engineering devices.

EE 505-506 Microwave Electronics (3-0) (3-0)6

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and traveling wave tubes.

EE 509-510 Transients in Electromechanical Systems (3-0) (3-0)6

Training in the formulation and solution of ordinary and partial differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems, with extensive use of modern operational mathematical techniques.

EE 511-512 Dynamic Control Analysis (3-0) (3-0)6

The principles of electronic devices used for control and measurement in applied science and engineering.

EE 513-514 Electromagnetic Theory (3-0) (3-0)6

Maxwell's equations, static and time-varying fields of charges and currents, energy and momentum relations, the wave equation, Poynting's vector, waveguides, special theory of relativity, retarded fields, radiation from accelerated charges and antennas, interaction of charged particles, and electromagnetic fields.

EE 521 Distributed Amplification (3-0)3
[EE 302, MA 312]

Basic concepts of distributed systems employing iterative structures; tube and transistor active elements in mixed lumped and distributed systems; and a discussion of millimicrosecond pulse measurement techniques.

EE 522 Parametric Amplification (3-0)3
[EE 302, MA312]

Treatment of linear and nonlinear systems with varying parameters; solutions to the Mathieu-Hill differential equation; amplification with non-storage and storage-type network elements; the pumped system with applications; and use of semiconductor devices as active network elements.

EE 529-530 **Network Synthesis** **(3-0) (3-0)6**

The formulation of the fundamentals of network theory; establishing realizability conditions and synthesis techniques for various classes of networks and network functions; and methods for realizing one or more networks whenever a function of the given class is prescribed.

EE 531-532 **Seminar in Electronics** **(1-0) (1-0)2**

Discussion by staff members and students of current journal publications and topics of current interest in electronic science, electronic engineering, and related areas of applied physics.

EE 533-534 **Special Problems in Electronics** **Credits to be arranged**

An opportunity for individual study, under the direction of a staff member, of topics in or related to electronic engineering.

EE 535-536 **Graduate Research** **Credits to be arranged**

Supervised research and thesis on some problem in electronic science, electronic engineering, or certain areas of applied physics.

INDUSTRIAL MANAGEMENT

IM 351 or 352 **Motion and Time Study** **(0-2)1**

The application of methods improvement and work measurement techniques. The use of the stop watch, work sampling, and operator charts in terms of application to standard systems such as M.T.M. and Work Factor.

IM 371 or 372 **Systems Engineering and Operations Research** **(3-0)3**

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 483 or 484 **Statistical Quality Control** **(3-0)3**
[MA 383 or 384 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 504 **Management of Computer Operations** **(3-0)3**

The use of digital computers in management problems. Programming of work on the Institute's 1620 computer installation.

IM 509 or 510 — Research Seminar — (3-0)3

[Permission of Department Head]

An opportunity for the advanced Industrial Management student to do research in an area of special interest under the direction of a member of the department.

LANGUAGES AND LITERATURE

LL 109-110 — English for International Students — (3-0) (3-0)6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 — English I and II — (3-0) (3-0)6

Training in the composition of extended exposition. Introduction to logic and to basic research techniques. Analysis and evaluation of collateral readings in the humanities. Introduction to literature.

LL 213 — Introduction to English Literature — (3-0)3

Interpretation and criticism of selections from the major writers in the chief periods of English literature.

LL 214 — Introduction to American Literature — (3-0)3

Interpretation and criticism of selections from the major writers in the chief periods of American literature.

LL 233 — Comparative Literature — (3-0)3

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 — Shakespeare — (3-0)3

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 261-262 — Elementary Technical German — (3-0) (3-0)6

An introduction to the study of the German language to develop a reading knowledge of scientific German. Limited practice in pronounciation and writing. No credit for the first semester without the second.

LL 263-264 — Elementary French — (3-0) (3-0)6

An introduction to the study of the French language to develop a reading knowledge. Limited practice in pronunciation and writing. No credit for the first semester without the second. For students who have had less than two years of secondary-school training in French.

LL 265-266 Elementary Technical Russian (3-0) (3-0)6

An introduction to the study of the Russian language to develop a reading knowledge of scientific Russian. Limited practice in pronunciation and writing. No credits for the first semester without the second.

LL 267-268 Elementary Spanish (3-0) (3-0)6

An introduction to the study of the Spanish language to develop a reading knowledge. Limited practice in pronunciation and writing. No credit for the first semester without the second. For students who have had less than two years of secondary-school training in Spanish.

LL 363-364 Intermediate French (3-0) (3-0)6
[LL 264 or equivalent]

Intended to increase reading knowledge and provide further training in speaking and writing. May be taken by students who have had two or more years of secondary-school training in French.

LL 365-366 Intermediate Literary and Conversational Russian (3-0) (3-0)6
[LL 266]

Intended to increase reading knowledge and to provide practice in speaking and writing. Russian essays and short stories of moderate difficulty with explanatory notes and vocabulary.

Offered in alternate years; not offered in 1965-66.

LL 367-368 Intermediate Literary and Conversational German (3-0) (3-0)6
[LL 262]

Intended to increase reading knowledge and to provide practice in speaking and writing. German essays and short stories of moderate difficulty with explanatory notes and vocabulary.

LL 369-370 Intermediate Spanish (3-0) (3-0)6
[LL 268 or equivalent]

Intended to increase reading knowledge and provide further training in speaking and writing. May be taken by students who have had two or more years of secondary-school training in Spanish.

LL 436 English Romanticism (3-0)3

A close study of the central works of Wordsworth, Coleridge, Blake, Byron, Shelley, and Keats, with emphasis on the sensibility peculiar to the poetic and philosophical attitudes of these writers.

LL 465 Advanced Seminar in Literary Russian (3-0)3
[LL 366]

Directed study in Russian fiction. Seminar reports on assigned topics are given in Russian every week by each student, orally or in written form as directed.

Offered in alternate years; offered in 1965-66.

LL 466 Advanced Seminar in Literary Russian (3-0)3
[LL 366]

Directed study in Russian nonfiction. Seminar reports on assigned topics are given in Russian every week by each student, orally or in written form as directed.

Offered in alternate years; offered in 1965-66.

LL 467 Advanced Seminar in Literary German (3-0)3
[LL 368]

Directed study in the works of two classical and two modern German writers. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

Offered in alternate years; offered in 1965-66.

LL 468 Advanced Seminar in Literary German (3-0)3
[LL 368]

Directed study in the works of leading German authors, primarily in the field of nonfiction. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

Offered in alternate years; offered in 1965-66.

LL 471 The Modern American Novel (3-0)3

A consideration of the outstanding American novelists from 1920 on. Selected works of Faulkner, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 World Drama (3-0)3

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 **Modern Drama** **(3-0)3**

An analysis of major forces in drama from the time of Ibsen to the present. Selected representative plays are read and discussed.

LL 482 **The American Short Story** **(3-0)3**

A critical survey of the growth and development of the American short story. Consideration of the works of Poe, Crane, Anderson, and others.

MATHEMATICS

MA 101 **Mathematical Analysis I** **(3-0)3**

[For students in Business Administration]

Number system, linear and fractional equations, exponents and radicals; functions and graphs, trigonometic functions, angular measure, quadratic equations, laws of variation, and functions of a composite angle.

MA 102 **Mathematical Analysis II** **(3-0)3**

[MA 101]

[For students in Business Administration]

Complex numbers, higher-degree equations, inequalities, logrithms, right triangles, oblique triangles, progressions, mathematical induction, binomial theorem, inverse trigonometric functions, permutations, combinations, probability, and determinants.

MA 107 **Calculus and Analytic Geometry** **(4-0)4**

Functions and graphs, equations of straight lines, the differentiation and integration of algebraic functions together with applications involving related rates, differentials, maxima and minima, Mean Value Theorem, areas, volumes, lengths of curves, areas of surfaces of revolution, center of mass, the theorems of Pappus, pressure, and work.

MA 108 **Calculus and Analytic Geometry** **(4-0)4**

[MA 107]

The differentiation of exponential, logarithmic, and trigonometric functions; integration by parts, integration by partial fractions, integration by trigonometric substitution, and other integral forms; determinants, both second and higher order; properties of roots of higher-degree equations; the conics; translation and rotation of curves, hyperbolic and inverse hyperbolic functions, polar coordinates, parametric equations, differentiation of vectors, and tangential and normal components of velocity and acceleration.

MA 201 **Mathematical Analysis III** **(3-0)3**

[MA 102]

[For students in Business Administration]

Analytical geometry, functions of one variable, differential calculus, integral calculus, functions of several variables, and differential equations.

MA 202 **Mathematical Analysis IV** **(3-0)3**

[MA 201]

[For students in Business Administration]

Set theory, vectors and matrices, probability theory, linear programming, and theory of games.

MA 205 **Calculus and Analytic Geometry** **(4-0)4**

[MA 108]

The scalar and vector products of two or more vectors, solid analytic geometry, space curves, curvature, arc length, partial differentiation, directional derivatives, gradient, chain rule, total differential, the method of least squares, maxima and minima of independent variables, line integrals, multiple integration, and three-coordinate systems; series, including Maclaurin, Taylor, and Fourier series, indeterminate forms, and test for convergence; and complex functions including the Argand diagram, DeMoivre's theorem, the Cauchy-Riemann equations, and logarithmic functions.

MA 206 **Differential Equations** **(3-0)3**

[MA 205]

The solution of ordinary differential equations and of partial differential equations of the first order and first degree and of forms in certain other orders and other degrees that lend themselves readily to solution. Practical applications to chemistry and engineering.

MA 301-302 **Advanced Calculus** **(3-0) (3-0)6**

[MA 206]

Ordinary differential equations, the Laplace transformation, numerical methods of solving differential equations, series solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, topics in higher-dimensional calculus, partial differential equations, partial differential equations of mathematical physics, and complex variable theory.

MA 305 or 306 **Theory of Equations** **(3-0)3**

[MA 108]

Mathematical induction, complex numbers, integral and rational roots, solution by radicals, impossibility of certain geometrical constructions, number of real roots, isolation of a root, determinants, and approximate methods of solution.

MA 311 **Engineering Mathematics** **(3-0)3**

[MA 206]

[For students majoring in Electrical Engineering]

Vector analysis, complex variable theory, ordinary differential equations, Laplace transformation, and numerical methods of solving differential equations.

MA 312 Engineering Mathematics (3-0)3

[MA 311]

[For students majoring in Electrical Engineering]

Series solutions of differential equations, boundary value problems and orthogonal functions, and partial differential equations with applications from mathematical physics.

MA 355 or 356 Digital Computer Programming (2-2)2

[Permission of instructor]

The programming and operation of the Institute's IBM 1620 digital computer and discussion of larger systems. Selected practice problems related to the specialties of the class are written by the students and tested to completion in the laboratory sessions.

MA 383 or 384 Statistical Methods (3-0)3

[MA 108]

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 401 or 402 Foundations of Mathematics (3-0)3

[MA 205]

The axiomatic method, set theory, transfinite arithmetic, the real number system, and philosophies of mathematics.

MA 403 or 404 Elementary Number Theory (3-0)3

[MA 205]

Properties of integers, including Euclidean algorithm, divisibility, diophantine equations, prime numbers, congruences, residues, and introductory number theory.

MA 405 or 406 Mathematical Statistics (3-0)3

[MA 205]

Measurements of dispersion, theoretical frequency distributions, tests of goodness of fit and independence, partial and multiple correlations; permutations, combinations, and probability; game theory.

MA 433* or 434* Matrix Algebra (3-0)3

[MA 205]

Algebra of vectors, matrices, and determinants; linear transformations; linear vector spaces; characteristic roots and reduction to diagonal form; quadratic forms; and applications to physics.

MA 459-460* Digital Computer Programming and Numerical Analysis (2-3) (2-3)6

Basic and advanced programming techniques in the use of high-speed digital computers for the solution of scientific and engineering problems. The preparation and running of sample problems on the Institute's IBM 1620 computer and at least one other larger computer. Numerical analysis techniques include simultaneous equations, least squares data fit, interpolation, numerical solution of differential equations, and other matters.

MA 484* Probabilities (3-0)3
[MA 302]

Elements of combinatorial analysis, introduction to probabilities, random variables and expectation, law of large numbers, central limit theorem, and elements of mathematical statistics.

MA 505-506 Mathematical Methods of Physics (3-0) (3-0)6

Elements of complex variables; Fourier and other transforms; ordinary differential equations and their classification, and Frobenius and other methods of solution; partial differential equations and their classification; boundary value problems, Sturm-Liouville theory and eigenvalues; vector spaces; Green's functions and integral equations of the first and second kind; and introduction to group theory.

MA 515 or 516 Methods of Applied Mathematics (3-0)3

The calculus of variations, integral equations, and applications.

MA 525 or 526 Modern Algebra (3-0)3

Topics in modern algebra, including number theory, equivalence relations, fields, integral domains, ideals, groups, Boolean algebras, sets, and matrices.

MA 533 or 534 Matrix Theory (3-0)3
[MA 433]

The calculus of matrices, including the study of matric polynomials, series of matrices, matric functions, and differentiation and integration of matrices; association of matrices with linear differential equations; and applications of matric methods to engineering.

MA 537-538 Group Theory (3-0) (3-0)6

Elements of set theory; mappings, isomorphisms, and cardinality; semigroups and groups; the theory of finite groups; general representation theory; and applications of group theory to quantum mechanics.

MA 541 or 542 Fourier Series and Boundary Value Problems (3-0)3

[MA 206]

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics, and boundary value problems.

MA 543 or 544 Partial Differential Equations I (3-0)3

[MA 302]

Ordinary differential equations in more than two variables, geomertical interpretations, partial differential equations of the first and second order, and boundary value problems.

MA 545 or 546 Partial Differential Equations II (3-0)3

[MA 543]

Partial differential equations of the second order, boundary value problems, and a detailed study of Laplace's equation, the wave equation, and the diffusion equation.

MA 553 or 554 Tensor Analysis (3-0)3

[MA 433 or 533]

The tensor concept; covariant and contravariant tensors; the metric tensor, associated tensors, and covariant differentiation; Euclidean and Riemannian manifolds; and applications to geometry and analytical mechanics.

MA 557-558 Computers (3-2) (3-2)8

[MA 302]

The principles of analog and digital computers as a basis for assessing and planning their use in scientific work. Logic design, instrumentation, programming, and numerical analysis. A survey of well-known commercial analog and digital computers. Experience with the computers at the Institute and also a visit to a local computing center having different equipment, during which a course-programmed problem may be run.

MA 563 or 564 Projective Geometry (3-0)3

[MA 205]

An introduction to various non-Euclidean geometrics. Point sets on a line, line pencils, homogeneous coordinates, and the theory of conics and quadrics. Multidimensional geometry, Plucker coordinates, and correlations and collineations in space.

MA 573 or 574 Functions of a Complex Variable (3-0)3

[MA 302]

Complex numbers, point sets, and elementary functions; an introduction to regular analytic functions; classification of singularities; and conformal mapping and applications.

MA 575 or 576 Operational Mathematics (3-0)3
[MA 302]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentiation, and integration. Elementary applications in the analysis of vibrations, deflections, and electric circuits; problems in partial differential equations; and Fourier transforms.

MA 585-586 Random Processes and Noise Theory (3-0) (3-0)6
[MA 302]

Principles of random noise theory and optimum filtering. Development of the concepts of correlation function and power spectra for the detection of signals in noise. Illustration of the theory in some applications of circuits and computers with emphasis on the formulation of the noise problem, its mathematical solution, and the interpretation of the results for proper design of systems.

MA 591 or 592 Graduate Thesis Credits to be arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

MA 595-596 Mathematics Seminar Credits to be arranged

Discussion of timely topics by visiting scientists, staff, and graduate students. Required of all graduate students.

MECHANICAL ENGINEERING

ME 101 Engineering Graphics (1-2)1

Communication by graphic representation — orthographic and pictorial. Charts and graphs. Freehand and instrumental multiview drawing, dimensioning, engineering geometry, pictorial sketching, and projection.

ME 102 Engineering Graphics (1-2)1
[ME 101]

The use of graphics in the solution of problems. Visualization by descriptive geometry, and its exercise in vector geometry and intersections. Graphical calculus, nomography, and empirical equations.

ME 211 **Applied Mechanics I** **(3-0)3**

[MA 108, PH 103]

[For students of Mechanical and Textile Engineering]

A development of fundamental ideas of mechanics such as vectors, forces, and moments. A detailed treatment of the free body diagram concept and its application to resultants of force systems, laws of static equilibrium, friction forces, first and second moments, and problems involving various structures and machine parts. First and second moments of scalar quantities are also considered.

ME 214 **Applied Mechanics II** **(3-0)3**

[ME 211]

[For students of Mechanical and Textile Engineering]

A continuation of ME 211. The basic laws of kinematics of particles and rigid bodies which involve linear, angular, relative, and absolute motion; Newton's laws and their application to the kinetics of rigid bodies in translation, rotation, and plane motion; and the principles of work, kinetic energy, impulse, and momentum.

ME 215 **Engineering Mechanics I** **(3-0)3**

[MA 108, PH 103]

[For students of Electrical, Chemical and Paper Engineering]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 **Engineering Mechanics II** **(3-0)3**

[ME 215]

[For students of Electrical, Chemical and Paper Engineering]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 261 or 262 **Machine Tool Laboratory** **(1-2)1**

The use of basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, gears, and gearing.

ME 263 or 264 **Metals Processing** **(1-2)1**

Modern methods of manufacture, including some of the more recent developments such as ultrasonic and chemical milling, explosive forming, and electrolytic grinding. Also the basic instruments used in metrology, such as hardness testers, optical flats, and optical comparators.

ME 311 **Applied Mechanics III** **(3-0)3**

[ME 211]

A basic course in strength of materials, including tension, compression, shear, and combined stresses; the Mohr circles for stress and strain; shearing force and bending moment diagrams; stresses and deflections of beams in bending; statically indeterminate problems; and torsion of circular sections and stresses in columns.

ME 313 **Mechanics of Solids I** **(3-0)3**

[For students majoring in Plastics Technology]

Statics of rigid bodies, energy principles, kinematics and dynamics of particles and rigid bodies, and introduction to vibrations.

ME 314 **Mechanical Engineering Laboratory I** **(0-3)1**

[ME 341]

Experimental work in the various fields of mechanical engineering to gain an appreciation of measurable quantities, analytical approaches, and measuring equipment and techniques. The design, analysis and synthesis of engineering systems are stressed throughout. The student is encouraged to devise his own experiments and to obtain and analyze the engineering data required for design.

ME 315 **Applied Mechanics** **(3-0)3**

[MA 108, PH 103]

[For students of Industrial Management and Paper Engineering]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 317 or 318 **Applied Mechanics IV** **(3-0)3**

[ME 214]

The fundamental ideas of statics and dynamics applied to general systems with oscillatory motion. The kinematics of periodic motion; free, undamped, damped, and forced vibration of systems with a single degree of freedom; and energy methods, systems with multiple degrees of freedom, and special methods for calculation of natural frequencies.

ME 341 **Thermodynamics** **(3-0)3**

[MA 205, PH 205]

Heat and work, the thermodynamic system, the first law of thermodynamics, open and closed systems, and steady-state and unsteady-state systems. The pure substance, the perfect gas, heat capacities, and the equipartition of energy principle. The second law of thermodynamics, the concept of reversibility, heat engines, and the thermodynamic temperature scale. Entropy and its relationship to probability, stability, and information. Availability and free energy.

ME 342 Thermodynamics (3-0)3

[ME 341]

Applications of the basic principles of thermodynamics; properties of thermodynamic media and their utilization; and combustion processes, flow systems, and power plant cycles.

ME 343 or 344 Heat and Power (3-0)3

[MA 108, PH 104]

[Not open to students in Electrical, Mechanical, or Textile Engineering]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 371 or 372 Strength of Materials (3-0)3

[ME 211, ME 315]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses, analysis of principal stresses, Mohr's circle of stress, and design of members and columns.

ME 374 Plastics Mold Design and Construction (1-2)1

[ME 261 or 262]

Principles of mold design and construction. The machining and finishing operations of plastics, and actual laboratory work in the design and construction of simple molds.

ME 375 or 376 Materials Science (3-2)3

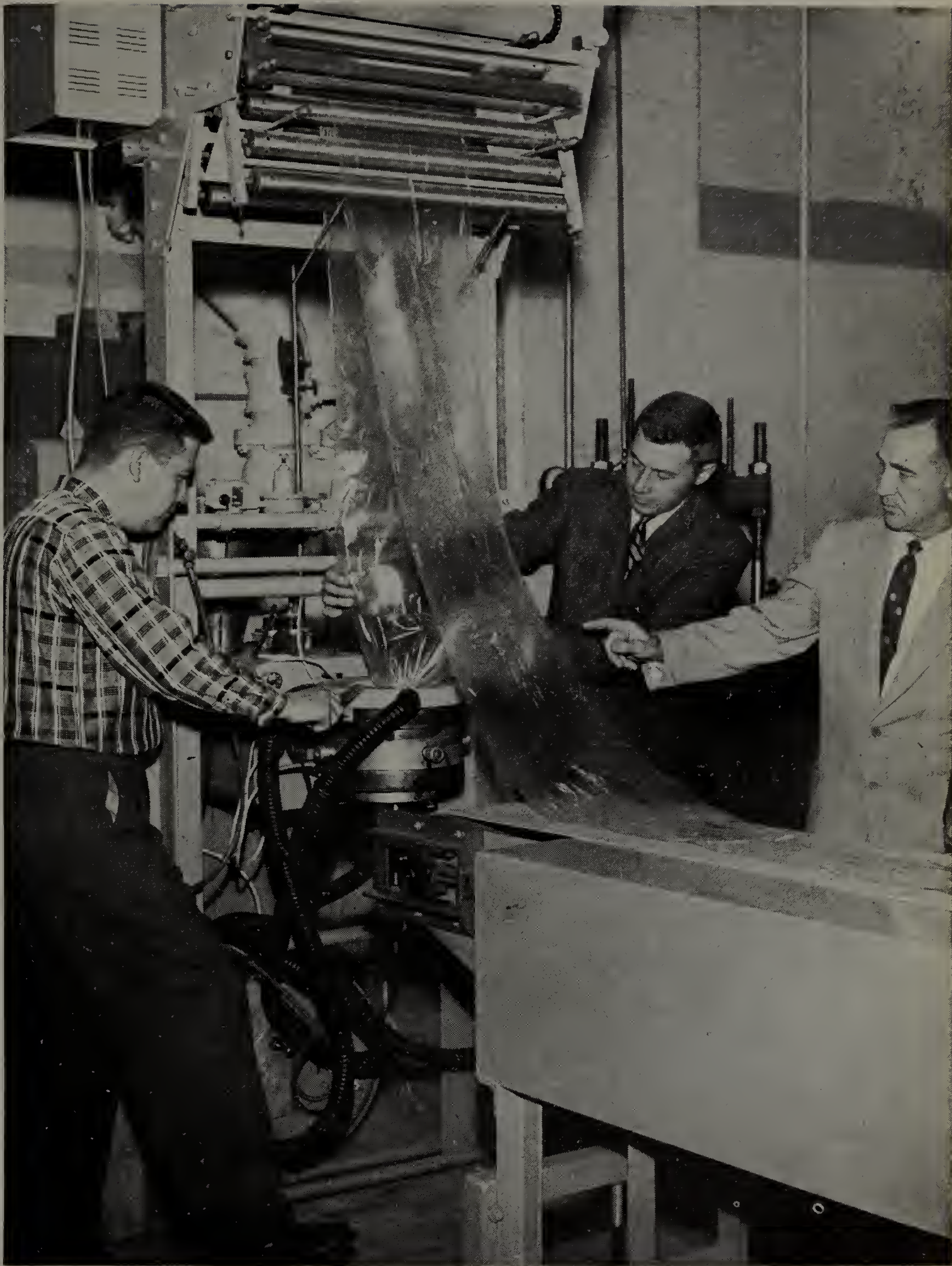
[PH 206]

The dependence of the properties of materials in general on atomic and crystalline structure. X-ray diffraction; equilibrium and rate processes; interatomic attractive forces; diffusion; theory of dislocations; mechanical, electrical, electronic, magnetic, and thermal properties. Standard physical tests and assigned projects are performed in the laboratory.

ME 377 Elements of Materials Science (2-0)2

[Not open to students in Electrical, Mechanical, or Textile Engineering]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, cold work, and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.



Plastics Extrusion Laboratory

ME 378 Mechanics of Solids II (3-0)3

[For students majoring in Plastics Technology]

Static and dynamic behavior of deformable systems. Stress and strain, torsion, compound stresses, analysis of plane stress and strain, failure theories, statically indeterminate members, stability and buckling, and stresses and deformations in bodies under dynamic loading.

ME 381 or 382 Fluid Mechanics (3-0)3

[MA 205, PH 205]

Definitions and fluid properties; fluid statics; fluid flow concepts and basic equations; reversibility and losses and thermodynamic relations. Dimensional analysis and dynamic similitude: pitheorem; viscous effects and fluid resistance: Reynolds number, boundary layer, drag on immersed bodies, duct losses, and Moody diagram. Compressible flow: Mach number, shock wave, and frictional and isentropic flow; closed- and open-conduit flow; fluid measurements; water hammer, surge, and cavitation phenomena; and turbomachinery.

ME 415 Mechanical Engineering Laboratory II (0-3)1

[ME 314]

Continuation of ME 314.

ME 416 Mechanical Engineering Laboratory III (0-3)1

[ME 415]

An individual project selected by the student in consultation with the staff. The project must include phases of design, construction, and analysis. Both a formal written report and an oral presentation are required.

ME 421-422 Machine Design (2-3) (2-3)6

[ME 214, ME 311]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes, bearings, gears, and cams. Theories of failure and methods of establishing working stress levels are considered. The laboratory work consists of comprehensive projects that illustrate the close relationship between analysis and synthesis as they are applied to various machine design problems.

ME 431 Power Plant Systems (2-3)3

[ME 342]

Elements of the design of power plants. Capacities and operating specifications are determined for the equipment of a power plant designed to produce electricity and processing steam for a manufacturing industry. Operating costs are computed based upon current prices of power plant machinery, fuel, labor, and the various necessary supplies.

ME 443 or 444 Heat Transfer (3-0)3

[MA 206; ME 341 and 382]

Modes of heat flow; combined heat transfer mechanisms: analogous electrical network; conduction (steady state and transient): exact and approximate methods of analysis (flux plot, Schmidt plot, finite differences); radiation heat transfer; dimensional analysis, fluid flow, and boundary layer theory. Reynolds analogy; Nusselt, Prandtl, Biot, Fourier, Graetz, and Grashof numbers; free convection; forced convections; heat transfer to boiling liquids and condensing vapors; and finned surfaces and heat exchangers.

ME 455 or 456 Information Processing Systems (2-2)3

[MA 356 or permission of instructor]

The use of electronic computing systems for the solution of engineering problems, with stress on symbolic programming methods. Student use of the IBM 1620 installation at the Institute is an integral part of the course.

ME 471 or 472 Experimental Stress Analysis (2-2)3

[MA 205, ME 311]

Photoelasticity, including introduction to the theory of elasticity, stress separation by shear difference, arithmetic iteration, oblique incidence, and lateral deformation. Photoelastic coatings; mechanical, optical, and electrical strain gages; brittle lacquer; and analogies.

ME 476 Physical Metallurgy (3-0)3

[MA 206; ME 375 or 376]

A study of metals. Phase diagrams and transformations, the system carbon-iron, electrical and magnetic properties related to structure, thermal and optical properties, elasticity and plasticity (including creep), diffusion, recovery, recrystallization, grain growth, hardening, and heat treatment. Interpretation of microphotographs of polished and etched specimens is stressed, as is the application of the theory to industrial problems involving the failure of metals in service.

ME 481 Orbital and Ballistic Mechanics (3-0)3

[ME 382]

Fundamental theorems on the mechanics of a free point mass, the classical two-body problem, and the equation for the trajectory of a point moving under the effect of the fundamental force of the earth's attraction. Impulsive powered flight, the magnitude of the flight velocity, flight altitude, flight time, angular flight range, and the direction of the flight velocity.

ME 491 or 492 Engineering Systems (2-0)2

Application of fundamental engineering principles in the solution of design problems which involve more than one engineering discipline, with emphasis on costs, useful life, reliability, safety, esthetics, miniaturization, maintainability, and interchangeability.

ME 493 or 494 Industrial Instrumentation (2-0)2

[MA 108, PH 104]

[Not open to students majoring in Electrical, Mechanical, or Textile Engineering]

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric, and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

ME 495 Electromechanical Engineering (3-2)4

[EE 204, MA 206]

Characteristics of electromechanical transducers and their associated circuitry as employed in the measurement of acceleration, velocity, displacement, stress, strain, thickness, mass, weight, frequency, time, and level of intensity.

ME 496 Electromechanical Engineering (3-2)3

[ME 495]

Servomechanisms and their application to control problems, with emphasis on system analysis by block diagram using transfer function techniques; and use of electrical analogs for analysis and design of mechanical systems.

ME 528 Kinematic Mechanism Synthesis (3-0)3

[ME 214]

Mechanism concepts, symbolic notations, coupler curves, and the Gruebler criterion. Planar linkage synthesis by geometric methods, synthesis of function generators and dwell linkages, and the Euler-Savary equation. Analytic methods of synthesis, Freudenstein's method, kinematics of spatial mechanisms, matrix representation of rotation, and general matrix methods of analysis.

ME 555 or 556 Advanced Computer Problems (3-0)3

[ME 455 or 456; permission of instructor]

An opportunity for students familiar with computers to develop advanced problem application of particular interest to them.

ME 576 Nondestructive Evaluation Techniques for Materials and Processes (3-0)3

[ME 318]

The nondestructive evaluation of materials and processes by penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitations of each. Particular emphasis is placed upon the analysis and correlations of the interactions of these energy forms with material properties and processes: flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical, and metallurgical properties.

ME 580 **Aero- and Astrodynamics** **(3-0)3**

[ME 382, ME 443]

The astronomical unit, the isothermal atmosphere, the troposphere, atmospheric stability, and potential temperature. Kepler's first, second, and third laws. The earth-moon orbital plane, acceleration in a satellite, and scalar equations for flight over a flat earth. The fundamental equations of entry dynamics and general aerodynamic heating analysis, ablation, and shield analysis. Minor-circle flight problems, dynamics of spinning (ballistic missiles), and trajectories. Performance of aircraft with parabolic polars, with arbitrary polars, and at high subsonic, transonic, and supersonic speeds.

NUCLEAR SCIENCE AND ENGINEERING

NU 301 or 302 **Nuclear Radiation and Radiological Safety** **(3-0)3**

The basic physics of alpha, beta, and gamma radiation, with emphasis on the more practical considerations. The absorption and scattering of gamma radiation with applications to the design of shielding systems for protection of personnel, and effects of intense radiation on biological systems, structural materials, and chemical reactions.

NU 351 or 352 **Nuclear Instrumentation I** **(2-4)3**

Electronic pulse circuitry, including amplifiers, discriminators, counting, coincidence, and pulse height circuits; and the measurement of resolving and response times. Specific experiments in nuclear instrumentation.

NU 401-402 **Nuclear Engineering** **(3-0) (3-0)6**

[MA 302; PH 366 or PH 344; NU 405-406 taken concurrently]

The design, construction, and operation of nuclear reactors, with emphasis on quantitative methods. The economic aspects of reactor use are stressed.

NU 403-404 **Reactor Instrumentation** **(2-4) (2-4)6**

Elements of servomechanisms; automatic control systems; electrical and electronic theory utilized in the measurement of reactor parameters such as reactivity, danger coefficients, and temperature coefficients; detection of neutron flux with fission, BF_3, and ionization chambers; analysis and design of power-measuring and period-measuring instruments; and calibration of control rods and general reactor control devices.

NU 405-406 **Reactor Theory** **(3-0) (3-0)6**

Review of nuclear physics, interaction of neutrons with matter, nuclear fission, neutron chain reaction systems, neutron flux and interaction rates, diffusion of neutrons, slowing down of neutrons, Fermi theory of the bare thermal reactor, multiregion reactors, the group diffusion method, and reactor kinetics.

NU 451 or 452 Nuclear Instrumentation II (3-0)3
[PH 366]

The general nature of detection systems; the interaction of ionizing-type radiations with matter; neutron detection; and characteristics of ionization chambers, proportional counters, Geiger-Mueller counters, and scintillation detectors.

NU 493-494 Nuclear Laboratory (0-6) (0-6)4
[Permission of instructor]

Characteristics of detectors, counting statistics, and calibration and use of instruments; properties of nuclear radiations, indicating ranges of alpha and beta particles, and absorption of gamma rays; neutron activation, radioactive decay, measurement of neutron flux, sigma piles, and gamma spectroscopy. Students may obtain partial credit for work on campus research projects with the approval of the instructor and the research project director.

PAPER

PA 201 Introduction to Paper Engineering (1-0)1

Major pulp and paper systems. Historical development of the paper industry and its economy. Available as an elective to students in other courses.

PA 301 Pulp Systems (3-0)3
[CH 205, CH 212, PA 201, or permission of instructor]

Lectures and problems involving the engineering, design, and technology of pulp manufacture by the groundwood, sulfite, alkaline, and semichemical processes. Studies of bleaching chemistry and methods.

PA 302 Paper Systems (3-0)3
[PA 301]

Lectures and problems involving the design, engineering, and technology of paper manufacture. Stock preparation, filling and loading, sizing, coloring, special additives, paper machine operation, and finishing. Chemistry of processes.

PA 303 Pulp Systems Laboratory (0-6)2
[Taken concurrently with PA 301]

Laboratory work designed with a research approach to develop the student's ability to plan, execute, and analyze experiments. Studies of principal wood, rag, wastepaper, and chemical pulps by microscopy and chemical methods. Bleaching and evaluation of pulps for papermaking value by TAPPI and other tests. Detailed written and oral reports are required.

PA 304 **Paper Systems Laboratory** **(0-6)2**
[Taken concurrently with PA 302]

The chemistry and engineering involved in the fundamental processing techniques of paper manufacture, including investigations of stock preparation, filling and loading, coloring, use of additives, and sheet formation. Use of TAPPI Methods. Detailed oral and written reports are required.

PA 403 **Converting Processes** **(3-0)3**
[PA 302, PA 304]

Lectures and problems concerning the engineering, design, and technology of paper and paperboard converting processes. Rheology of coating materials and engineering properties of materials. Mechanical, coating, impregnating, and printing processes.

PA 405 **Converting Processes Laboratory** **(0-6)2**
[Taken concurrently with PA 405]

Common techniques employed in the paper and paperboard industry and use of TAPPI Methods. Emphasis is placed on the colloidal and rheological properties of materials used. Detailed written and oral reports are required.

PA 410 **Advanced Paper Engineering Seminar** **(3-0)3**
[PA 403]

Individual research projects involving engineering, design, and chemical problems of certain aspects of paper manufacturing and converting. Extensive written and oral reports. Plant visits in specialized subjects.

PA 501-502 **Graduate Thesis** **Credits to be arranged**

Every graduate student is required to write a thesis on original research work done under the supervision of a senior staff member, and this thesis must be approved by an examining committee appointed by the Department Head.

PA 503-504 **Advanced Converting Processes** **(3-0) (3-0)6**
[PA 403, PA 405]

Specific converting processes; coating operations, both water-based and solvent-based; and the latest techniques used by the converting industry, including mechanical and chemical operations. Oral and written reports are required. Plant visits of specific converting problems.

PA 505 **The Physics of Paper** **(3-0)3**

Structures of fibers from a fundamental viewpoint and their effect on strength and other properties of sheets made from these fibers. Comparison of cellulosic fibers and synthetic fibers. Engineering properties of fiber materials.

PA 506 New Techniques in the Paper Industry (3-0)3

A seminar to discuss new developments in engineering, design, and the application of physical and chemical principles in the manufacture of paper and paper products. Economic studies of new processes. Plant visits; oral and written reports.

PA 508 Advanced Paper Systems Analysis (3-0)3

Chemistry and engineering principles applied to non-fibrous components in papermaking.

PHYSICS

PH 101-102 General Physics (3-0) (3-0)6

[For students majoring in Business Administration]

Mechanics, heat, wave motion, sound, light, electricity and magnetism, and modern physics. Lectures and experimental demonstrations.

PH 103 Physics (4-1)4

[MA 107 taken concurrently]

The principles of mechanics, including physical measurement, composition and resolution of vectors, motion in one dimension and in a plane, particle dynamics, work and energy, conservation of energy, conservation of linear and angular momentum, rotational kinematics and dynamics, statics of rigid bodies, mechanical oscillations, and gravitation.

PH 104 Physics (4-2)4

[PH 103 or equivalent; MA 108 taken concurrently or previously]

The principles of electricity and magnetism. Charge and matter, electric fields, Gauss's law, electric potential, capacitance and inductance, and transients in circuits containing inductance, capacitance, and resistance. Magnetic fields, Ampere's law, Faraday's law, and electromagnetic oscillation.

PH 205 Physics (4-2)4

[MA 205 taken concurrently; PH 104]

Temperature; heat and the first law of thermodynamics; kinetic theory of gases, including specific heats; and the second law of thermodynamics. Mechanical oscillators; traveling elastic waves; standing waves; acoustical and optical wave phenomena, such as beats, the Doppler effect, reflection, refraction, interference, and diffraction; polarization; and spectra.

PH 206 **Physics** **(4-2)4**

[PH 205]

Modern physics, including the atomic nature of matter and electricity, variation of mass with velocity, isotopes, the nature of radiant energy, black bodies and the origin of the quantum theory, photoelectricity, spectra, Bohr's theory of the atom, X-ray spectra, waves associated with material particles, the spinning electron, Pauli's principle, magnetic moment of an atom, the periodic system and quantum numbers, molecular structure, radioactivity, elementary particles, scattering and absorption of particles and photons, transmutation, fission, reactors, fusion, cosmic rays, mesons, hyperons, and relativity.

PH 208 **Modern Physics** **(3-2)4**

[PH 205]

[For students majoring in Nuclear Engineering]

Charged particle motion in electromagnetic fields, black body radiation, the photoelectric effect, the special theory of relativity, the Bohr atom, quantum mechanics, X-ray scattering and absorption, Compton scattering, and the kinetic theory of gases.

PH 210 **Practical Astronomy** **(3-0)3**

[MA 205]

Coordinate systems, marine navigation, space navigation, the gravitational potential, Kaplerian orbits, and the rendezvous problem in space. The material is developed mainly through the solution of problems.

PH 242 **Modern Physics** **(4-2)4**

[PH 205]

[For students majoring in Physics or Nuclear Science]

The special theory of relativity, thermal radiation, black body radiation, Planck's theory of black body radiation, discovery of the electron, classical and quantum theories of the photoelectric effect, the Compton effect, Thompson's description of the atom, the Rutherford experiment, atomic spectra, Bohr's theory of the one-electron atom, the Wilson-Sommerfeld quantization rule, Sommerfeld's relativistic theory, DeBroglie's theory, the uncertainty principle, formulation of Schrodinger's equation, and the energy quantization of a free particle.

PH 244 **Optical Instruments** **(1-2)2**

[PH 205 taken concurrently]

The basic laws of optics and their application to various optical instruments used in industry, such as the microscope, telescope, refractometer, and colorimeter. Considerable emphasis in the laboratory work is placed on the general use of the microscope.

PH 251 **Intermediate Electricity** **(3-3)4**

[MA 205 and PH 205 taken concurrently]

Electric field, potential, Gauss's law, dipoles, Poisson's and Laplace's equations, image problems, dielectric theory, energy, capacitance, force, electric current, d.c. circuits, steady magnetic fields, electromagnetic induction, magnetic properties of matter, L-C-R circuits, analysis of a.c. circuits, and Maxwell's equations.

PH 253-254 **Introductory Field Theory** **(3-0) (3-0)6**

[MA 108 and PH 104; MA 205-206 taken concurrently]

[For students majoring in Electrical Engineering]

The fundamental laws of electricity and magnetism presented from the point of view of field theory. Free use is made of the calculus. Electrostatics, steady currents and their magnetic fields, induced electromotive forces and inductance, time-dependent magnetic fields, and electromagnetic waves in free space, on wires, and in material bodies. Behavior of electrons in metals, thermionic emission, dielectric and magnetic properties of matter, geometrical optics, physical optics, atomic structure, and topics in modern physics.

PH 258 **Electrical Measurements** **(2-3)3**

[MA 205, PH 205]

Precision of measurements, zero-frequency and low-frequency measurements by both deflection and null methods, amplifiers and tube electrometers, oscilloscopes, oscillographs, Geiger and proportional counters, magnetic measurements, and electrical measurements in mechanics, heat, acoustics, optics, and nuclear science.

PH 311-312 **Intermediate Mechanics** **(3-0) (3-0)6**

[MA 206]

Vector analysis, statics of systems of particles, rectilinear motion of a single particle, the linear oscillator, motion in two and three dimensions, Stokes' theorem, conservative forces, central field motion, motion of systems of particles, generalized coordinates and momenta, Lagrange's equations, motion of rigid bodies, the spinning top, the coupled oscillator, normal coordinates, and the vibrating string.

PH 321 or 322 **Intermediate Thermodynamics** **(3-0)3**

[MA 206]

Analysis of temperature, thermodynamic systems, ideal gases, the first and second laws of thermodynamics, reversible processes, the Carnot cycle, entropy and its philosophical significance, properties of pure substances, and various applications.

PH 323 or 324 — Introduction to Statistical Mechanics — (3-0)3

[PH 312 taken concurrently; PH 321]

Introduction to probability theory, classical Maxwell-Boltzmann statistics, classical statistical mechanics, statistical mechanical interpretation of thermodynamics, and applications to the kinetic theory of gases.

PH 343-344 — Atomic and Nuclear Physics — (3-0) (3-0)6

[MA 206, PH 206; PH 311-312 taken concurrently]

Atoms as components of matter; particle beams in electric and magnetic fields; and magnetic, optical, and electrical properties of atoms. X-rays, photons and X-ray spectra, optical spectra, the special theory of relativity, the Schrodinger equation, and electron spin and multiplet spectra. Radioactivity, Rutherford scattering, nuclear radii, wave mechanics, cross sections, and nuclear reactions.

PH 345-346 — Atomic and Nuclear Physics — (3-0) (3-0)6

[MA 206, PH 206; PH 311-312 taken concurrently]

[For students in the Physics Honors Course]

The special theory of relativity; relativistic mechanics; scalar invariants, 4-vectors, and tensors; the Lorentz transformation and particle collisions; an introduction to quantum mechanics; and the one-electron atom. The Pauli exclusion principle; atomic shell structure, the multielectron atom, and atomic spectroscopy; the Zeeman effect, the Stark effect, and the Paschen-Back effect; basic properties of nuclei; charge, mass, and magnetic moments; radioactivity; and excited nuclear states and nuclear reactions.

PH 347 or 348 — Physical Optics — (3-0)3

[PH 353 or 354]

The theoretical and experimental aspects of the phenomena of interference, diffraction, and polarization of electromagnetic waves, especially light and microwaves.

PH 353-354 — Electromagnetic Theory — (3-0) (3-0)6

[MA 301-302 taken concurrently; PH 205]

The theory of electromagnetic fields using vector analysis and Maxwell's equations. Static electric and magnetic fields in dielectrics, conductors, and ferromagnetic materials; the scalar and vector potentials and time-varying fields; and the special theory of relativity. Plane waves in dielectrics and conductors, the Poynting vector, Fresnel's equations, and waveguides; radiation from antennas and accelerated charges; polarization, interference, and diffraction; and receivers.

PH 355-356 **Electromagnetic Theory** **(3-0) (3-0)6**

[MA 301-302 taken concurrently; PH 205]

[For students in the Physics Honors Course]

Forces and fields; Maxwell's equations; electrostatics: expansion in multipole moments, Poisson's and Laplace's equations, and images; magnetic fields; and scalar and vector potentials. Electromagnetic induction, energy density and Poynting vector, and the equation of continuity. The electromagnetics of material media: polarization, dielectrics, and magnetization. Physical optics: reflection and refraction of electromagnetic waves, Fermat's principle, Huygens' principle, and Fraunhofer and Fresnel diffraction. The Special Theory of Relativity, space-time and field transformations, relativistic dynamics, the electromagnetic field tensor, and the covariant formulation of physical laws. Radiation from accelerated charges. The scattering of electromagnetic waves.

PH 363 or 364 **Introductory Nuclear Physics** **(3-0)3**

[MA 206, PH 208]

[For students majoring in Nuclear Engineering]

Natural radioactivity; the Bateman equations; isotopic abundance; induced activity; the energetics of nuclear reactions; and alpha, beta, and gamma emission.

PH 365 or 366 **Intermediate Nuclear Physics** **(3-0)3**

[PH 363]

[For students majoring in Nuclear Engineering]

The compound nucleus and resonance theory, cross sections, Rutherford scattering, center of mass coordinates, neutron physics, nuclear radii, nuclear stability and forces between nucleons, and nuclear models.

PH 394 **Physics Laboratory** **(0-3)1**

[Permission of instructor]

The student is afforded an opportunity to perform significant experiments in various areas of physics.

PH 411-412* **Quantum Theory** **(3-0) (3-0)6**

[MA 433 and MA 484 taken concurrently; PH 311 or 312]

The beginnings of the quantum theory. The Bohr-Sommerfeld theory; wave-particle dualities and the uncertainty principle; the DeBroglie theory; basic principles of wave mechanics; Schrodinger's equation and applications; operators and observables; commuting properties of operators and their relationships to the uncertainty principle; mathematical theory of eigenfunctions, Fourier series, and the Fourier integral; matrix mechanics; perturbation theory by wave and matrix mechanics; and applications.

PH 425 or 426 — Meteorology — (3-0)3
[MA 205]

Introduction to meteorological science; the atmosphere, clouds and precipitation, heat and temperature changes, radiation balance and global circulation, equations of motion, air masses and fronts, cyclones and tropical storms, and climatology; observations and analyses; maps and forecasts.

PH 431 or 432* — Theory of Vibrations and Sound — (3-0)3
[MA 301, PH 312]

Free, damped, and forced oscillations; forcing by pulses; coupled oscillations; the flexible string; end conditions; perturbations; the vibration of bars, membranes, and plates; sound waves; acoustic impedance; the radiation and scattering of sound; normal modes; and reverberation. Applications are stressed.

PH 443 or 444 — Spectrographic Methods — (2-3)3
[PH 206]

A course exploring the merits of spectroscopy as a tool for the investigating scientist. The theoretical prediction of line and band spectra and the theory and operation of various spectrograph designs.

PH 445 or 446 — X-Ray Diffraction — (1-6)3

Theory of X-ray production; absorption; scattering by electrons and atoms; crystallographic notation; Laue equations; and determination of crystal structure. For those whose background interests involve fibers, some opportunity for investigation of these is offered in the laboratory work.

PH 447 or 448 — Electron Microscopy and Electron Diffraction — (2-3)3
[PH 206]

Analogies with optics, electrostatic and magnetic lenses, electron trajectories, the scattering of electrons, electron diffraction and the wave properties of the electron, vacuum techniques, thin films by vacuum evaporation and electropolishing, specimen preparation, qualitative and quantitative evaluation of the electron image, and photographic techniques.

PH 449 or 450 — Infrared Radiation — (2-3)3
[PH 206]

The use of infrared radiation as a means of scientific investigation. The laws and theories of black body radiation, including those of Planck, Wien, and Stefan-Boltzmann. The theory and operation of various infrared detectors and systems of collecting optics.

PH 453 or 454 **Piezoelectric Crystals** **(2-3)3**

[PH 311, PH 353]

Phenomena in piezoelectric crystals and measurements of related quantities. Parameters of the equivalent circuit of a resonator, vibrational modes, elastic coefficients and temperature effects, the consequences of cutting plates of different orientations, and effects of surface shaping. Applications such as in transducers, frequency stabilization, ultrasonic wave generation, wave filtering, and clock control.

PH 461 or 462 **Nuclear Physics** **(3-0)3**

[MA 302; PH 344 or 366]

Ionization of matter by charged particles, mass-energy relationships, packing fraction, elementary discussion of properties of a nucleus, radioactive decay, systematics of alpha and beta decay, alpha decay theory, gamma emission, two nuclear systems, nuclear reactions and nuclear structure, and properties of neutrons.

PH 471-472* **Solid-State Physics** **(3-0) (3-0)6**

[PH 411-412 taken concurrently]

Crystal structure and X-ray and neutron diffraction; free electron model; band theory of solids; quantum mechanical considerations; lattice energy, lattice vibrations, and infrared absorption; lattice defects; thermal properties of solids; dielectric and magnetic properties; mechanical properties; and semiconductor crystals.

PH 493-494 **Advanced Laboratory** **(1-3) (1-3)4**

[Permission of instructor]

A laboratory course which accompanies the senior courses in the department and which may serve as a vehicle for undergraduate experimental research in selected fields of physics.

PH 495 or 496* **Special Research Problems** **Credits to be arranged**

[Permission of Head of Department and instructor]

Special problems in theoretical and experimental physics assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

PH 497-498* **Biophysics Seminar** **(1½-0)1**

A seminar-type course with students leading discussions on almost any topic of physical interest in biology. An attempt is made to survey this vast field, but emphasis is mainly on the physics of the sense organs, nerve conduction, and muscle contraction; the effects of radiation on living cells; molecular biology; applications of information theory to biology; and descriptions of some of the newer instrumentation for research.

PH 507 or 508 High-Energy Physics (3-0)3

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation laws of high-energy physics, strong and weak interactions, and an introduction to the theory of unitary symmetry and its consequences.

PH 511-512 Classical Mechanics (3-0) (3-0)6
[PH 312]

Lagrange's equations, Hamilton's principle, holonomic and nonholonomic constraints, the two-body problem, matrix formulation of rigid body motion, Hamilton's equations, principle of least action, canonical transformations, Hamilton-Jacobi theory, and the theory of small oscillations.

PH 515-516 Quantum Mechanics (3-0) (3-0)6
[MA 433, PH 411; PH 511-512 taken concurrently]

Wave packets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum, spin, and time-dependent and independent perturbation theory. Scattering theory.

PH 517 or 518 Advanced Quantum Mechanics (3-0)3
[PH 516]

The formal theory of scattering. The Klein-Gordon and Dirac equations, the Foldy-Wouthuysen transformation, elements of covariant perturbation theory based on Feynman's propagator approach, and renormalization theory. Second quantization and canonical commutation rules, the connection between spin and statistics, the TCP theorem, and selected topics in strong and weak interactions.

PH 519 or 520 Theory of Weak Interactions (3-0)3

The four-Fermi interaction, beta decay, two-neutrino theory, violation of space and time symmetries, conservation laws and selection rules, conserved vector current, SU(3) transformation properties of the weak Lagrangian, and electron and muon neutrinos and the intermediate vector boson.

PH 521 or 522 Statistical Mechanics (3-0)3
[PH 324]

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and Bose-Einstein, and applications to thermodynamics, solid-state physics, and nuclear physics.

PH 523 or 524 **Low-Temperature Physics** **(3-0)3**
[MA 302; PH 321 or 322]

The production of low temperatures; temperature measurement; liquid helium; superfluids and superconductors; paramagmetic salts; the magnetic temperature scale; nuclear polarization and alignment; thermal conductivity at low temperatures; the third law of thermodynamics; and adiabatic demagnetization.

PH 531 or 532 **Acoustics** **(3-3)4**
Not offered in 1965-1966.

PH 537 or 538 **Group Theory** **(3-0)3**
Group theory and its application to the quantum theory, symmetry properties and conservation laws, crystalline fields, Lie groups, an analysis of the rotation and Lorentz groups, a general analysis of SU(n), and applications.

PH 552 **Astrophysics** **(3-0)3**
[PH 206, PH 311]

The origin and future of the universe, using mathematical treatment wherever practicable. Theorems needed beyond the prerequisites are developed in the course.

PH 553 or 554 **Piezoelectricity and Ferroelectricity** **(3-3)4**

Crystallographic bases of piezoelectricity, crystal elasticity, rotated axes, modes of vibration; behavior and interactions of the elastic, dielectric, and piezoelectric coefficients; ferroelectric crystals, domain structure, transitions between phases, free and clamped states; and applications of piezoelectric and ferroelectric crystals.

PH 555 or 556 **Plasma Physics** **(3-0)3**
[PH 354]

The production of high-intensity electromagnetic and electrostatic fields and the interaction of these with conducting forms of matter. The physics of high-temperature, low-density gases, with emphasis on practical applications.

PH 557-558 **Electricity and Magnetism** **(3-0) (3-0)6**
[MA 301-302, PH 353-354]

Electrostatics and magnetostatics with special attention to boundary-value problems. Quasistatic fields and displacement currents, Maxwell's equations, the Special Theory of Relativity, Lienard-Weichert potentials, and radiation from an accelerated charge. Waveguides, scattering, and applications to the problems of modern-day physics.

PH 561 or 562 **Nuclear Physics** **(3-0)3**
[PH 462]

Stationary states of nuclei, nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles, gamma rays, and neutrons; nuclear forces and nuclear models; and fast neutron physics.

PH 563 or 564 **Microwave Spectroscopy** **(3-3)4**
Not offered in 1965-1966.

PH 565 or 566 **Nuclear and Electron Spin Resonance Phenomena** **(3-0)3**
[PH 411-412 taken concurrently]

An introduction to crystal field theory and electron spin resonance; coupling of angular momenta; nuclear electric quadrupole and magnetic resonance; application to gases, liquids, and crystals; and a survey of experimental techniques.

PH 567 or 568 **Neutron Diffraction Analysis** **(3-0)3**
The diffraction of neutrons in crystals and its applications in the determination of lattice structures and magnetic moments.

PH 571-572 **Lattice Imperfections** **(3-0) (3-0)6**
A description of point, line, and plane imperfections in crystals, and their properties, causes, and interactions; the influence of imperfections on electron and phonon transport phenomena and also on lasers; a study of imperfections by X-ray and electron diffraction; and a discussion of problems in current literature.

PH 575-576 **Problems in Solid-State Physics** **(3-0) (3-3)7**
Quantum mechanics and specific heats, lattice energy, elastic coefficients, applications of statistical mechanics, ferroelectric crystals, diamagnetism and paramagnetism, Brillouin zones, Hume-Rothery rules, order-disorder transformations, semiconductors, ferromagnetism and antiferromagnetism, ferrimagnetism, magnet relaxation and resonance, superconductivity, lattice vacancies, diffusion, color centers, excitons, dislocations, and thermal and electrical conductivity at low temperatures.

PH 577-578 **Thermodynamics of Solids** **(3-0) (3-0)6**
The thermodynamics of first- and second-order phase changes; lattice energy and vibration spectrum; the Einstein-Debye model; nonideal solid solutions; order-disorder phenomena; crystal interfaces and imperfections; and applications to metals and semiconductors.

PH 581 or 582 Information Theory (3-0)3

A definition of information and its identification with entropy; a critical examination of codes and written and spoken languages; the Tuller-Shannon formula and the capacity of channels with noise; and autocorrelation techniques and their application. Physical analogs of communications problems are stressed throughout.

PH 583-584 General Theory of Relativity (3-0) (3-0)6

The invariance of physical laws; tensor formulation of the special theory of relativity and applications; and the general theory of relativity.

PH 591 or 592 Master's Thesis Credits to be arranged

The thesis for the master's degree covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the department head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

PH 593-594 Graduate Laboratory Credits to be arranged
[Permission of instructor]

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics.

PH 595-596 Physics Seminar Credits to be arranged

A discussion of timely topics by visiting scientists, staff, and graduate students. Required of all graduate students.

PH 601-602 Special Problems in High-Energy Physics Credits to be arranged

PH 603-604 Special Problems in Solid-State Physics Credits to be arranged

PH 605-606 Special Problems in Nuclear Physics Credits to be arranged

PH 651-652 Physics Seminar in High-Energy Physics Credits to be arranged

PH 653-654 Physics Seminar in Solid-State Physics Credits to be arranged

PH 655-656 Physics Seminar in Nuclear Physics — **Credits to be arranged**

PH 701-702 Research in High-Energy Physics — **Credits to be arranged**

PH 703-704 Research in Solid-State Physics — **Credits to be arranged**

PH 705-706 Research in Nuclear Physics — **Credits to be arranged**

PLASTICS

PL 201-202 Introduction to Polymeric Materials (2-0) (2-0)4

A descriptive subject to acquaint the student with plastics as a class of materials. The history, definitions, classes, properties, and applications of plastics.

PL 301-302 Plastics Technology (2-2) (2-2)6

[PL 201 or permission of instructor]

Raw materials and manufacturing processes. Methods of processing plastics materials, including compounding, molding, casting, extruding, laminating, fabricating, and finishing. Evaluation and development of typical plastics problems. Laboratory instruction in the processing and fabrication of plastics materials.

PL 401-402 Plastics Technology (2-3) (2-3)6

[PL 301-302]

Application of plastics as engineering materials. Product, equipment, and mold design. Correlation of composition, processing, and fabrication with product design and applications. Continuation of laboratory instruction in processing, molding, and fabrication.

PL 403-404 Properties of Polymers (0-3) (0-3)2

[Open to seniors only]

Correlation of composition and structure with important engineering properties of plastics; environmental conditioning and effects of types of loading in evaluation of plastics materials; the theory of testing; critical examination of testing techniques, equipment, and standard ASTM methods of evaluating mechanical, thermal, electrical, and optical properties.

PL 411-412 Plastics Seminar (1-0) (1-0)2

[Open to seniors only]

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics technology.

PL 413-414 Introduction to Polymer Physics (2-0) (2-0)4

[Open to seniors only]

Chemical bonding in polymers, energy dispersion, segmental and molecular motion, freezing and melting, glass transition temperature, crystallinity, rubber elasticity, swelling, viscoelasticity, mechanics of network response, electrical and optical properties of polymeric networks, and of the physics of combined materials.

SOCIAL SCIENCES

SS 102 Foundations of National Power (2-0)2

[For non-ROTC freshmen only]

The principles of United States foreign policy and the role of the country in contemporary world politics.

SS 223-224 The United States Since 1865 (2-0) (2-0)4

The study of the advancement of the American people from the Reconstruction era to the present. With special permission the first semester may be taken alone for credit.

SS 225 or 226 Europe: 1789-1914 (3-0)3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 227 Europe: 1914-1939 (3-0)3

A study of the quarter-century in which the "Great War" and the postwar settlements and realignments created a new Europe and set the stage for World War II. Emphasis is given to the rise of totalitarianism and the changing power patterns in Continental Europe and the world at large.

SS 228 Europe: 1939 to the Present (3-0)3

A survey of the major events of World War II and the key factors in the postwar alignments. Particular attention is given to the roles of Soviet Russia and the United States, the effects of regionalism and internationalism, the decline of imperialism, and the economic, political, and social developments in the world's major nations in our time.

SS 301 Government of the United States (3-0)3

The process of policy-making in Congress and the Presidency with particular attention to the location of power in the government, both in theory and in practice.

SS 302 Conduct and Control of Foreign Policy (3-0)3

A seminar considering the ways a state's conduct of its foreign policy affects, and is affected by, both the substance and processes of its domestic politics. Primary consideration is given to the United States and the principal nations of Western Europe, but examples are taken from other nations as well.

SS 303 or 304 Psychology (3-0)3

The place of psychology in the life of the individual and society, with emphasis on the psychological bases of behavior and attitude in their relations to personal, industrial, and community experiences.

SS 305 or 306 Sociology (3-0)3

The principles of sociology, including the development of man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 371 or 372 American Civilization to 1865 (3-0)3

A study of the development of national consciousness in America through a review of the evolution of economic, political, and social institutions and their influences upon U. S. culture.

SS 403 World Politics: Principles, Structures, Cases (3-0)3

An examination of theories of international relations as a framework for an analysis of the elements, organization, strategies, and controls of world politics by a historical case method.

SS 459 World Politics: The Central Problem of War (3-0)3

War as the central phenomenon of world politics — its causes and functions in theory and history, its effects on the individual and society, efforts to control it, and ethical problems raised by it.

SS 460 Foreign Aid and Foreign Policy (3-0)3

A seminar considering the difficulties involved in stabilizing areas threatened by communism and insurgency which lie outside the line of containment. Discussions involve changing approaches to foreign aid, and relations of western powers, Congress and the State Department, and various other departments and agencies involved in foreign policy operations.

SS 464 World Politics: Problems of International Organization (3-0)3

International and regional organizations both as mirrors of contemporary world politics and as forces of change. The history and theories of international organization, constitutional problems, the poltical and non-political functions of the UN system; the development, varieties, and significance of regionalism; and the relations between traditional and parliamentary diplomacy.

SS 471 The United States in World Politics (3-0)3

The principles behind American foreign policy and an eclectic inquiry using a case study into the circumstances under which these principles have been utilized by the United States.

SS 472 Defense Policy (3-0)3

A seminar revolving around the relationship of force and foreign policy in the thermonuclear age. Discussions involve policymaking and organization, military strategy and foreign policy, and the substance of national security.

SS 477 or 478 Twentieth-Century Russia (3-0)3

The objective of this subject is twofold: to give the student an understanding of the Russian people, the Empire, and the Soviet Union through a study of backgrounds, and to make possible a comprehension of the structure, aims, and methods of the Soviet regime and its present role in world affairs.

SS 479 or 480 The Far East Since 1900 (3-0)3

Basic historical and cultural backgrounds of the peoples of East Asia surveyed as a preface to a study of the economic, political, and social development of the mainland and island states, with emphasis on the interests and policies of European nations and the United States.

SS 481 or 482 The Greeks and Western Civilization (3-0)3

Contributions of the ancient Greeks to our culture. The influences of Greek thought, arts, and politics studied through selected readings and discussions in seminar meetings.

SS 483 Political and Social Thought: Ancient Times to Early Modern Times (3-0)3

Studied in the works of great writers of political and social philosophy from Plato through Machiavelli. Class discussion with the purpose of tracing the origins and development of humanism, asceticism, communism, fascism, and democracy.

SS 484 Political and Social Thought: Early Modern Times to Present (3-0)3

Studies in the origins and development of modern political and social ideologies. Class discussion with the purpose of relating ideologies to institutional conflicts.

SS 485 or 486 The Romans and Western Civilization (3-0)3

Roman contributions to western culture and politics, with emphasis on Roman legal and governmental concepts and institutions.

SS 487 American Political Thought to 1865 (3-0)3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0)3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and the postwar years.

SS 489 or 490 Nationalism and Imperialism Since 1800 (3-0)3

The origins and development of nationalism and imperialism and the effects of these phenomena upon the nations of Europe. Attention is given to interpretations of these subjects as well as to historical events. A written assessment of the significance of these phenomena in the modern period is required.

TEXTILE CHEMISTRY

TC 201 Introduction to Textiles (2-0)1

The history, economics, and geographical distribution of the textile industry and its interrelationships with the chemical and fiber-producing industries. The basic principles, nomenclature, and sequences of the physical and chemical processes of the textile industry.

TC 202 Chemistry and Physics of Fibers (3-0)3

The structure and chemical reactions of linear high polymers of importance in the field of natural and synthetic fibers; the chemical and physical structure of polymers and fibers; the relation of molecular length, orientation, crystallinity, intermolecular attractions, side chains, and flexibility of polymers to the physical properties of fibers; and chemical reactions of polymers and their effects on fibers.

TC 301 The Purification of Fibers (2-3)3

The chemical and physical nature and properties of impurities in natural and man-made fibers and the mechanisms of their elimination. The theory and principles of fiber purification discussed in lectures are evaluated by laboratory and pilot-plant experimental study.

TC 311 Chemical Textile Testing (3-0)3

Qualitative and quantitative methods for determining fiber content, finishing agents, and dyestuffs, including optical methods of analysis and evaluation.

TC 403 The Principles of Dyeing and Printing (2-6)4

The principles of dyeing and printing commercially important fibers with the more important classes of dyes and pigments. Lectures, laboratory experimentation, and pilot-plant problems are integrated to illustrate basic principles of dyeing methods, color prediction, compatibility of dyes in mixtures, basic variables of machine design, the control of nonuniformity, and the principles of phase transfer of dyes in printing.

TC 404 Theory of Dyeing (3-4)4

Mechanisms of reactions in the dyeing of fibers which emphasize basic physical and chemical variables affecting equilibria, rates of dyeing, and diffusion. Quantitative studies on the kinetics and equilibria of dyeing reactions are conducted in the laboratory.

TC 411 Chemical Technology of Finishing I (3-1)3

Conversions of fabrics from the gray state for utility, serviceability, or appearance. Stress is placed both on the chemical phases and on essential engineering principles. Lectures, seminars, and laboratory workshops.

TC 412 Chemical Technology of Finishing II (3-2)4

Continuation of TC 411.

TC 502 Theory of Dyeing (3-4)4

[For Graduate Students]

Same as TC 404 but with added assigned reading and reports.

TC 505 Physical Chemistry of Dyeing (3-0)3

Lectures and exercises on the physicochemical principles involved in the application of dyestuffs to textile materials, including both the thermodynamics and kinetics of dyeing.

TC 541-542 Graduate Thesis Credits to be arranged

An independent investigation of a problem in textile chemistry in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

TEXTILES

TE 212 Fiber Science (3-1)3

The different fibers and their origin and properties. The effect of molecular arrangement in fibers upon the chemical, physical, and mechanical behavior of the raw material and upon their technological utilization. Polymer structure, order, intermolecular forces, flexibility, and other properties in the light of stress-strain relationships, such as viscoelastic behavior. These and other factors as design elements leading to the prediction of the physical properties of textile systems, as well as the geometry of yarns and fabrics and their behavior characteristics.

TE 322 **Yarn Technology** **(2-2)3**

Advanced processing techniques, with the use of equipment illustrating all systems common to the U. S. standards.

TE 363 **Textile Systems I** **(3-1)3**

Fiber preparation processes as systems in yarn manufacture presented analytically in terms of engineering principles or mechanisms leading to an understanding of the functional use, structural design, and basic geometry of yarns.

TE 364 **Textile Systems II** **(3-2)3**

The concepts of fabric design: an analysis of the effects of mechanical processing upon structural relationships, with stress on physicomechanical and chemical behavior.

TE 366 **Textile Systems III** **(2-1)2**

A study and analysis of the physical behavior of gray fabrics as mechanical systems during the finishing operations. Major emphasis is on absorption, pressure, heat transfer, and the physical and mechanical design principles involved. Laboratory is demonstration only.

TE 367 **Textile Systems IV** **(2-1)2**

The basic chemical structure of the fibers within the fabric and the relationship which such a system has with the application of dye and finish due to chemical transition catalysis, electrostatic attraction, covalent and other bonding forces, etc., in effecting an acceptable end product.

TE 411-412 **Fundamentals of Textiles — Yarns** **(2-2) (2-2)6**

Designed to familiarize students with the basic machines and techniques for the production of yarns regardless of the fibers and/or production systems used. Primary emphasis is upon the mechanical principles employed.

TE 431-432 **Fundamentals of Textiles — Fabrics** **(2-2) (2-2)6**

Designed to familiarize students with the basic machines and techniques for the production of fabrics regardless of the fibers and/or yarns employed, from the preparation of yarns for fabrication to the actions and modifications available for the production of fabrics. Primary emphasis is upon the mechanical principles employed.

TE 434 **Knitting Fundamentals** **(2-1)2**

A broad survey of the mechanics of knitting equipment and the varied fabrics produced therefrom.

TE 435 **Fabric Technology** **(3-2)4**

A thorough study of design, weaving, and knitting as applications of science to the construction of fabrics.

TE 457-458 **Technology of Finishing** **(2-0) (1-2)4**

Lectures and laboratory workshops in the major engineering and chemical considerations necessary to finish fabrics of all fibers. The engineering aspects are stressed.

TE 459 or 460 **Textile Drying — Theory and Practice** **(1-0)1**

The engineering concepts used in textile drying equipment, including extractive drying in addition to conduction, convection, radiation, and dielectric types. The theory and fundamentals of heat transfer as used in textile drying.

TE 471 or 472 **Textile Evaluation** **(2-3)3**

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 474 **Instrumentation for Textiles** **(2-2)3**
[EE 204]

A study of indicating and recording instruments used to measure such common textile process variables as pressure, temperature, humidity, liquid level, fluid flow, etc. Response characteristics of mechanical, electrical, and electronic systems, and process characteristics and their effects upon the selection of the correct mode of control.

TE 482 **Application of Scientific Methods to Textile Processes** **(3-0)3**
[MA 206, ME 341]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483*-484* **Engineering Design of Textile Structures** **(3-0) (3-0)6**

[MA 205, TE 364]

This subject correlates engineering properties of textile materials, engineering principles, and textile processing in the design of textile structures with desired properties. The geometry of yarns and fabrics; design of textile structures for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes which the end use imposes; analyses of load-elongation diagrams of textile structural material.

TE 501-502 **Structure and Properties of Fibers** **(3-0) (3-0)6**

[Permission of instructor]

The molecular structure and arrangements of molecules in fibers are considered with respect to giving a foundation to the understanding of the physical and mechanical properties and behavior of these textile raw materials. These properties are examined from a fundamental viewpoint so that a sound approach to the technological utilization of fibers in textiles can be established. Such aspects as polymer structure, order, intermolecular forces, and flexibility, as they relate to stress-strain characteristics, viscoelastic behavior, etc., are discussed as well as the effects of environmental conditions on these factors. An introduction is made to the interrelation between fiber properties and yarn and fabric geometry in determining the behavior of textiles.

TE 503 or 504 **Technology of Cotton Fibers** **(2-2)3**

[Permission of instructor]

Effects of various chemical, mechanical, and growth modifications of cotton on the chemical, physical, and processing properties of the cotton fiber. Problems are assigned for laboratory evaluation, and a paper for class delivery is required of each student.

TE 517 or 518 **Product Quality: Cotton System Yarns** **(2-2)2**

[Permission of instructor]

Devoted to a study and analysis of product defects in the manufacture of yarns on cotton system machinery. Procedures necessary to avoid the defects are studied, and the diagnostic ability of the student to recognize and remedy defects is developed.

TE 519 or 520 **Multifiber Processing: Cotton System Yarns** **(2-2)2**

[Permission of instructor]

The blending and processing of various fibers utilizing cotton system machinery, with emphasis upon fiber properties and yarn characteristics.

TE 537 or 538 — Fundamentals of Jacquard Fabrics — (1-1)1

[Permission of instructor]

Sketching of original designs as applied to particular Jacquard fabrics, transfer of design to cross-section design paper, choice of weave structure for both the background and foreground, cutting and lacing of cards, and weaving of sample length of fabric.

TE 539 or 540 — Complex Woven Structures — (2-1)2

A study of Leavers lace design and production theory, production machinery, and manufacture. The same aspects of Schiffli-embroidery are covered, as well as the fundamentals pertaining to chenille, Wilton, Brussels, tapestry, velvet, and Axminster carpets.

TE 545 or 546 — Weaving Laboratory — (0-3)1

[Permission of instructor]

Designed to provide additional time for the student in the weaving laboratory so that greater familiarization with the operation of various loom mechanisms may be acquired.

TE 571 — Textile Microscopy — (2-3)3

The principles involved in the use of the microscope for the qualitative and quantitative estimation of the morphological, physical, and chemical properties of textile materials.

TE 573 or 574 — Mechanical Testing of Textiles — (2-3)3

Thickness and compressional measurements, stress-strain-time phenomena of viscoelastic textile materials, Vibroscope theory and techniques, yarn uniformity, thermal determination, and friction evaluation are among the major topics covered. Emphasis is placed on current literature search assignments and the preparation of a student paper on a selected topic within the scope of the subject.

TE 585 — Textile Plants Organization — Yarns — (3-0)3

Designed to correlate the various aspects of yarn production. Emphasis is placed upon the need for proper balance among machinery elements for the production of specific yarn types. Consideration of machinery layouts for efficient and economic operation of the total yarn establishment, with stress on the various calculations involved. Considerable use is made of the case history technique of presentation.

TE 586 — Textile Plants Organization — Fabrics — (3-0)3

Similar in concept to TE 585 except that the subject pertains to the production of fabrics.

TE 590 **Graduate Seminar** **(2-0)0**

Introduction to thesis material and thesis preparation.

TE 591-594 **Thesis Seminar** **Two hours per week**
No credits

Required of all graduate students in Textile Engineering. Devoted to problems in the preparation and presentation of research work, with illustrative material drawn from thesis work in process.

TE 595-596 **Graduate Thesis** **Credits to be arranged**

Each graduate student in Textile Engineering is required to submit a thesis which shows ability and originality in the solution and presentation of a research project.

Paper Engineering Laboratory

Textile Engineering Laboratory

THE GRADUATE SCHOOL

INTRODUCTION

The Lowell Technological Institute Graduate School, founded in 1935, offers graduate programs in the following areas:

Master of Science Programs

Chemistry	Paper Engineering
Electrical Engineering	Physics
Leather Chemistry	Textile Chemistry
Mathematics	Textile Technology

Doctor of Philosophy Programs

Chemistry

- **a.** high polymer
- **b.** organic
- **c.** physical

Physics

- **a.** experimental
- **b.** theoretical

Because of the varied objectives of the graduate students, each specific course of study is arrived at through consultation with the student's graduate adviser or advisory committee. Each program includes an original thesis.

ADMISSION

General Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training are considered. Selection of applicants admitted is based upon their ability to pursue graduate work of high quality.

Special Student Status

An applicant who meets the general admission requirements but who wishes to concentrate on specific subjects or special research programs may request special student status. Acceptance is contingent upon the consent of the instructor in charge of each subject to which admission is desired, and the work does not lead to a degree.

Normally a special student may not change his status to that of a student working for a graduate degree. If a special student wishes to work for a degree, he must apply in writing to the Director of the Graduate School. If the application for change in status is approved, all of the credit earned as a special student may not necessarily be allowed for degree credit.

Provisional Status

An applicant for admission who is unable to meet all the requirements for general admission may be accepted provisionally if he satisfies the department in which he wishes to enroll that he is probably able to pursue graduate studies successfully.

The status of a provisional graduate student may be changed to full graduate status upon demonstration of his ability to pursue graduate studies successfully as measured by the completion of his first semester's work with a minimum of a B— average in subjects taken for credit toward the graduate degree.

Application Procedure

Applications may be obtained from the Office of the Graduate School. They should be completed and returned to the Director of the Graduate School not later than June 1 preceding the fall term in which the applicant wishes to enroll. Applications must be supported by letters from at least two persons qualified to judge the ability of the applicant to carry on graduate work and research. The letters should be sent directly from these persons to the Graduate School.

Transcripts of all undergraduate records (and graduate, if any) must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with approprepriate seals and signatures. Records, descriptions of subjects, and letters must be in English. Each subject must be described in terms of content, scope, number of hours per week, and number of weeks duration. Lecture and laboratory time should be properly distinguished. If a catalogue giving such descriptions in English is available, the subjects taken may be clearly marked in a copy sent to the Graduate School.

Credit may be given for graduate subjects taken at other colleges if the grade received is at least B and if these subjects were not used in earning another degree. All applicants must submit an additional copy of transcripts which include the subjects for which transfer credit is desired. Not more than 10 credit hours for the master's degree or more than 22 credit hours for the doctor's degree may be transferred. No transfer credit can be offered for the thesis requirement for any graduate degree. Transfer credit for subjects taken at other colleges before initial enrollment at Lowell Technological Institute must be cleared within four weeks after the student's first registration. No transfer credit for such subjects is given after this period.

In addition to returning a completed application form and having transcripts and letters sent, the applicant must take the Graduate Record Aptitude Test and have the results sent to the Director of the Graduate School. Information regarding the Graduate Record Aptitude Test may be obtained from Educational Testing Service, 20 Nassau Street, Princeton, N. J., or Box 27896,

Los Angeles 27, Cal., whichever office is nearer to the applicant. All fellowship applicants must also take the appropriate Advanced Test administered by the Educational Testing Service.

Because most subjects are presented in lecture form, students from other countries should have a reasonably fluent command of the English language before applying for admission. All students from countries where English is not the national language must pass an English Language Proficiency Test before they can be accepted into the Graduate School. This test may be taken at any U. S. consular office.

Except in unusual circumstances, applications are acted upon and the applicant is notified of the decision by July 1. Foreign applicants are urged to apply as early as possible so as to leave enough time for visa and other arrangements to be made.

ACADEMIC EXPENSES

Tuition (per year)	
U. S. citizens who are residents of Massachusetts	$200
All others	$600
Student Activity and Insurance Fund (per year)	49
Commencement Fee	15

In addition, every graduate student is required to bear the cost of binding at least two copies of his thesis for the Institute's files. Some divisions may require more than two bound copies. Students are not permitted to register for thesis work until these fees have been paid at the library.

FELLOWSHIPS

No special applications are required, but students who wish to be considered for fellowships must have their completed graduate school application material, including transcripts and letters of reference, sent to the Director of the Graduate School no later than April 1.

All fellowship applicants must take the appropriate Advanced Graduate Record Examination as well as the Aptitude Tests on or before the March examination date.

Teaching Fellowships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends range from $1500 to approximately $2500 per academic year, depending on the nature of the appointment, and reappointment in succeeding years is contingent upon satisfactory performance of duties. Appointees are expected to carry up to a half-time teaching load primarily involving supervision of undergraduate laboratories and review sections.

Research Fellowships

The Lowell Technological Institute Research Foundation sponsors a limited number of research fellowships for graduate study in Physics. A stipend of $2500 plus tuition and fees is granted for one calendar year. The recipient carries a full graduate program during the fall and spring semesters and conducts his thesis investigation during the summer.

National Science Foundation Cooperative Graduate Fellowships

The Institute is a participant in the National Science Foundation's Cooperative Graduate Fellowship Program. These fellowships are awarded on the basis of ability. Candidates must be citizens of the United States on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute prior to beginning their fellowship tenures.

The stipend provided by the NSF for Cooperative Graduate Fellows is $2400-$2800 for those on a tenure of 12 months and $1800-$2100 for those on a tenure of nine months. There is also an allowance of $500 for each dependent. Tuition and fees are paid by the NSF directly to the Institute.

One of the requirements for applying for an NSF Fellowship is to take the Educational Testing Service Graduate Record Examinations (Aptitude Test and one Advanced Test in the area of specialization). Because the application deadline for the fellowships is in the first part of November, it is important to make arrangements to take these tests early.

National Science Foundation Graduate Traineeships

The National Science Foundation has awarded a grant to the Institute for the support of a limited number of Graduate Trainees in Physics. The stipend and citizenship limitation are identical with the Cooperative Graduate Fellowships described above.

MASTER OF SCIENCE DEGREE PROGRAMS

Chemistry

This program provides opportunity for advanced study and research training in chemistry, both general and specialized. Provision also is made for the student to elect certain advanced subjects in related fields of mathematics, physics, and engineering.

Evaluation Examination — During the weeks of registration each entering student must present himself the four three-hour written evaluation examinations in the fields of organic chemistry, physical chemistry, inorganic chemistry, and analytical chemistry. In addition he must take a laboratory proficiency examination. These examinations are scheduled and administered by the Department of Chemistry, and the results serve as a guide for the student and advisory committee in planning the program of study. All entering students must take these examinations regardless of previous training.

Subject Requirements — Of the 20-credit minimum, exclusive of thesis and seminar, required in listed subjects (see Requirements for Graduation) a minimum of 15 credits must be taken in chemistry. Of these not more than 12 credits may be taken in approved undergraduate subjects, although normally credit is not allowed for undergraduate subjects in the major field of specialization, e.g., organic, physical, inorganic. Recommended subjects include CH 423-424*, CH 431-432*, CH 443-444*, and all 500 courses in chemistry. Each graduate program must include subjects in organic chemistry, inorganic chemistry, and physical chemistry. All students must take CH 507-508, Chemistry Seminar. The remaining credits (five or more) may be taken in chemistry or in a related field such as physics, mathematics, or engineering. All subjects must be approved by the student's advisory committee.

Language Requirements — The student must demonstrate his ability to read technical German. For details concerning the language examination, see the section on Doctor of Philosophy Degree Program.

Advisory Committee — The development of the student's program of study is the responsibility of an advisory committee consisting of three members from the faculty of the Division of Chemistry and Applied Chemistry. This committee is appointed by the Director of the Graduate School upon the recommendation of the division chairman and includes the thesis supervisor.

Thesis Examination — Each candidate for the Master of Science degree in Chemistry, upon completion of his thesis, must present himself for an oral examination in the field of his thesis before an examination committee appointed by the department head and consisting of his advisory committee and other appropriate faculty members. While only members of the examination committee and the Director of the Graduate School may conduct the examination, all faculty members may attend. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the last semester. Each student has the right to one re-examination within a period of one year.

Electrical Engineering

This graduate program offers to a limited number of selected students opportunity for individualized work in the more advanced areas of electronics with emphasis on analytic methods of analysis and synthesis.

Leather Chemistry

Opportunity for graduate research in Leather Chemistry is provided through this program. In general only those students either possessing the B.S. degree in Chemistry or having a strong background in chemistry are acceptable as candidates for the M.S. degree.

The curriculum in Leather Chemistry is similar to that required for the M.S. degree in Chemistry, and subject requirements are identical. No language requirement is involved, but CH 507-508, Chemistry Seminar, must be taken each semester the student is in residence. Opportunity is provided for conducting research in chemistry as applied to the composition and technology of leather, and laboratory facilities for processing and testing leather are available.

Each student upon entering the curriculum must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry.

Thesis Examination — Upon completion of the thesis, each candidate for the degree of Master of Science in Leather Chemistry must present himself for an oral examination in the field of his thesis to an examination committee appointed by the department head. This examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester.

Mathematics (see **Physics and Mathematics**)

Paper Engineering

This program provides for advanced study and research training in Paper Engineering and allied subjects, with specific application to papermaking and paper converting.

The Paper Engineering Department will consider applicants in the following categories:

(a) graduates of the Lowell Technological Institute B.S. Paper Engineering program;

(b) B.S. graduates in Paper Engineering or Paper Technology from other universities;

(c) general B.S. or M.S. graduates in Egineering or Chemistry with no previous training in Paper Engineering.

Students with the backgrounds of **(a)** or **(b)** should be able to complete the work in one academic year. Students in group **(c)** should be able to complete the degree requirements in two academic years.

Required Subjects

1.	PA 501-502	(Graduate Thesis) — A minimum of 8 credits.	
2.	PA 503-504	Advanced Converting Processes	(3-0) (3-0)6
	PA 505	The Physics of Paper	(3-0)3
3.	One of the following:		
	PA 506	New Techniques in the Paper Industry	(3-0)3
	PA 508	Advanced Paper Systems Analysis	(3-0)3

4. A minimum of 9 credits from the following:

CH	503-504	Chemistry of High Polymers	(3-0) (3-0)6
CH	512	Physical Chemistry of Surface-active Agents	(3-0)3
CH	513	Chemical Applications of Spectroscopy and Spectrophotometry	(3-0)3
CH	514	Physicochemical Methods	(2-0)2
CH	538	Rheology	(3-0)3
CH	540	Chemical Kinetics	(3-0)3
CHE	407	Industrial Chemistry I	(3-0)3
CHE	408	Industrial Chemistry II	(3-0)3
CHE	503-504	Absorption and Extraction	(3-0) (3-0)6
CHE	505	Colloid Chemistry for Chemical Engineers	(3-0)3
CHE	511 or 512	Structure and Property of Matter	(3-0)3
EC	414	Engineering Economy	(3-0)3
MA	301-302	Advanced Calculus	(3-0) (3-0)6
MA	383 or 384	Statistical Methods	(3-0)3
ME	493 or 494	Industrial Instrumentation	(2-0)2

5. Thirty credits are required for the degree, but additional undergraduate subjects may be required of students who have deficiencies in their prior training. Technical electives must be approved by the Head of the Department of Chemical Engineering and Paper Engineering.

Physics and Mathematics

The graduate programs in Physics and Mathematics provide an opportunity for advanced study and the development of research capacity in physics or mathematics or both. The laboratories of the department are well set up for investigations in crystal physics and other aspects of solid-state physics, with excellent equipment in X-rays, spectroscopy, and electron microscopy. Equipment in nuclear physics is constantly being added.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis, required in listed courses (see Requirements for Graduation) 15 credits must be taken in physics and mathematics. The remaining credits (five or more) may be taken in a related field. Of the total credits at least 12 must be in subjects numbered 500 and above. A reasonable and consistent program of study is prepared by the student and his advisory committee. This committee consists of two or more members from the faculty of the Division of Physics and Engineering Science, one of whom is the thesis supervisor. The committee is appointed by the department head. Entering students who are found to be deficient in any areas of the undergraduate curriculum in Physics may be required to take appropriate courses in that curriculum.

Language Requirements—The student must demonstrate his ability to read technical German or Russian.

Thesis Examination — Each candidate for the Master of Science degree in this department, upon completion of his thesis, must present himself for an oral examination in the field of his thesis to an examination committee appointed by the department head and consisting of his advisory committee and other appropriate faculty members. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the last semester. Each student has a right to one re-examination within a period of one year.

Textile Chemistry

The graduate program in Textile Chemistry provides opportunity for advanced study and research in chemistry as applied to textiles and textile auxiliary agents. Formal subjects and research facilities are provided for training in fiber science and in the chemistry of the various processing operations applied to fibers, yarns, and fabrics, including dyeing, finishing, and fiber modifications.

Each student upon entering the curriculum must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry.

The M.S. degree in Textile Chemistry normally requires two years for completion except in those instances where the student possesses previous training in this field sufficiently extensive to meet departmental standards.

First Semester

CH	331	Physical Chemistry	(3-3)4
MA	383	Statistical Methods	(3-0)3
TC	301	The Purification of Fibers	(2-3)3
TC	403	The Principles of Dyeing and Printing	(2-6)4
TC	411	Chemical Technology of Finishing I	(3-1)3
		Total hours	(13-13)17

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	334	Colloid Chemistry	(3-0)3
TC	202	Chemistry and Physics of Fibers	(3-0)3
TC	412	Chemical Technology of Finishing II	(3-2)4
TC	502	Theory of Dyeing	(3-4)4
		Total hours	(15-9)18

Third Semester

CH	501	Interpretation of Data	(3-0)3
TC	505	Physical Chemistry of Dyeing	(3-0)3
TC	541	Graduate Thesis	5
TE	571	Textile Microscopy	(2-3)3
		Total credit hours	14

Fourth Semester

CH	502	Absorption Spectrophotometry and Color Measurement	(2-3)3
CH	512	Physical Chemistry of Surface-active Agents	(3-0)3
CH	538	Rheology	(3-0)3
TC	542	Graduate Thesis	5
		Total credit hours	14

Depending upon previous baccalaureate preparation, exemptions on some of the above subjects may be allowed. However, no exemptions will be allowed on any graduate subject (subjects with numbers in the 500's).

Textile Technology

This graduate program is offered to qualified students in the field of textiles, with primary emphasis upon either the engineering or physical aspects of the field. Ample opportunity is afforded for study and research in the physical and mechanical properties of fibers and textile structures and methods of evaluating them. Work at an advanced level on the structural design of textiles, processing principles, and manufacturing equipment is also available. Applicants should have a B.S. degree in Textile Engineering or Technology, Mechanical Engineering, or Electrical Engineering. Applicants with degrees in other areas, however, are given consideration.

Diagnostic Examinations — All entering students who have had previous training in Textile Technology are required to take diagnostic examinations during registration week. The subject areas tested are Fundamentals of Yarns, Fundamentals of Fabrics, Finishing Statistics, and Statistical Quality Control. Students are required to take diagnostic examinations only in subjects in which they have had previous training. Those who demonstrate proficiency in diagnostic examinations are exempt from taking the corresponding subjects during their program at the Institute.

Subject Requirements — The following suggested curriculum is recommended for most students. Those who demonstrate proficiency in diagnostic examinations are exempt from taking the corresponding subjects. Students whose background is deficient in engineering or mathematics are required to fake additional subjects. Those subjects designated by a dagger (†) represent minimum degree requirements.

First Semester

MA	383	Statistical Methods	(3-0)3
TE	411	Fundamentals of Textiles — Yarns	(2-2)3
TE	431	Fundamentals of Textiles — Fabrics	(2-2)3
TE	457	Technology of Finishing	(2-0)2
TE	471	Textile Evaluation	(2-3)3
TE	501	Structure and Properties of Fibers	(3-0)3
		Total hours	(14-7)17

Second Semester

TE	412	Fundamentals of Textiles — Yarns	(2-2)3
TE	432	Fundamentals of Textiles — Fabrics	(2-2)3
TE	434	Knitting Fundamentals	(2-1)2
TE	458	Technology of Finishing	(1-2)2
TE	474	Instrumentation for Textiles	(2-2)3
TE	502	Structure and Properties of Fibers	(3-0)3
TE	592	Thesis Seminar	(2-0)0
		Total hours	(14-9)16

Third Semester

TE	483*†	Engineering Design of Textile Structures	(3-0)3
TE	593†	Thesis Seminar	(2-0)0
TE	595†	Graduate Thesis	3
		Technical Electives	9
		Total credit hours	15

Fourth Semester

TE	484*†	Engineering Design of Textile Structures	(3-0)3
TE	594†	Thesis Seminar	(2-0)0
TE	596†	Graduate Thesis	3
		Technical Electives	9
		Total credit hours	15

Technical Electives must be chosen from the 500 series of textile subjects. Students with no prior background in textiles are required to take additional subjects, including:

TE	212	Fiber Science	(3-1)3
TE	363	Textile Systems I	(3-1)3
TE	364	Textile Systems II	(3-2)3

Thesis Examination — Each candidate for the Master of Science degree in Textile Technology, upon completion of his thesis, must take an oral examination in the field of his thesis. This examination is conducted by a committee appointed by the Director of the Graduate School which must include the thesis supervisor and advisers of the candidate and any additional faculty members desired by the Director. Any faculty members may attend, but only members of the examination committee may conduct the examination. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the semester in which the student expects to be a candidate for the degree. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the designated semester. If the student fails the oral examination, he has the right to one re-examination within a period of one year. Failure in

the re-examination requires the satisfactory completion of a new thesis subject and the accompanying oral examination.

MASTER OF SCIENCE DEGREE REQUIREMENTS

Term of Residence

Applicants with sufficient background in their chosen field of concentration normally require one academic year of residence to complete the requirements for the master's degree. Those with no background require a minimum of two years of residence.

Graduates of other colleges usually need more than one academic year to fulfill the degree requirements, even though they majored as undergraduates in their graduate field of specialization.

All requirements for the master's degree must be completed within five years after the student's entrance. Extension of time beyond this limit may be granted only with joint approval of the student's adviser (or advisory committee), his department head, his division chairman, and the Director of the Graduate School.

Requirements for Graduation

To be recommended for the Master of Science degree a candidate must:

1. Complete a course of study approved by the department in which he has been enrolled. The approved course of study must have a minimum of 30 credit hours, including thesis. A minimum of 20 credit hours must be spent in listed subjects, and the program should have no fewer than five credit hours of thesis work.
2. Complete a thesis (original research or other investigation, optional with the department) approved by the department in which he has been enrolled, and successfully pass any oral or written examinations on his thesis required by the department at the time his thesis is submitted for final approval. The only grades given for thesis work are S (satisfactory) and U (unsatisfactory). All theses should be submitted in final form to thesis advisers on or before May 15.
3. Maintain residence for at least one academic year.
4. Maintain at least a B— average in all work in formal subjects offered for the degree. The lowest grade acceptable for graduate credit is C. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work but which are taken during his enrollment as a graduate student must be passed with a grade of at least C; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.

5. Fulfill departmental language requirements.
6. Satisfy all requirements as to tuition and fees.

PH.D. PROGRAM IN CHEMISTRY

Objectives

The doctoral program in Chemistry is designed to provide both advanced knowledge and research training in chemistry, particularly in the fields of organic and physical chemistry and polymer science, with emphasis in the field of textiles for those so desiring.

Plan of Program

The doctoral degree normally requires from three to four years of study beyond the bachelor's degree or a minimum of two to three years beyond the master's degree.

The plan of study pursued by each student is dependent on individual requirements and is developed through conference with his advisory committee or, pending its appointment, with his temporary adviser.

All students entering the doctoral program must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry. Only those students who have taken these examinations previously as candidates for the Master of Science program will be excused.

The initial part of the student's program, normally completed at the end of two years of study, is devoted to formal course work. His first year is usually given to subjects in the major branches of chemistry in preparation for his qualifying (candidacy) examinations. The second year is devoted primarily to advanced subjects in a special field of concentration in preparation for the comprehensive examinations.

The second and final part of the program is devoted principally to research leading to the doctoral thesis. However, the student is encouraged to begin research as early as possible in his program of study.

Upon entrance to the doctoral program, each student is assigned an advisory committee. This committee is appointed by the Director of the Graduate School, based upon recommendation by the Chairman of the Division of Chemistry and Applied Chemistry, and consists of at least three members of the faculty. Of these at least two must be from the faculty of the Division of Chemistry and Applied Chemistry. One member of the committee representing the student's major field of interest serves as temporary chairman. After the student has selected his thesis supervisor, the temporary chairman of the advisory committee is replaced by the thesis supervisor, who then serves as permanent chairman.

Examinations for Doctoral Students in Chemistry

Qualifying Examinations — Three written qualifying examinations are given by the Chemistry Department, each involving one full day. These examinations

cover the fields of organic chemistry, physical chemistry, and inorganic-analytical chemistry. Before the student can be admitted to candidacy for the doctorate, he must pass all three examinations.

Qualifying examinations are given in all fields twice each year, in September during or before the week of registration and in June following the final examination period. All three qualifying examinations must be attempted not later than the beginning of the third semester of graduate study in the doctoral program (normally in September of the second year), though any one or all may be attempted earlier. In cases of failure, re-examinations may be taken only during the June period. A second failure in any one of the examinations results in automatic dismissal from the doctoral program. All qualifying examinations must be passed before the beginning of the third year in the program.

The comprehensive examination is in two parts, a written examination lasting one day and covering the field of the major, and an oral examination in defense of a proposition.

The written examination is given once a year in September. It should be taken as soon as possible after completion of the bulk of course work in listed graduate subjects in the field of specialization. However, it must be taken not later than the beginning of the fourth year of study in the doctoral program. Where it is necessary to carry less than the normal credit load of 12+ per semester, the student must apply for extension beyond this deadline to the chairman of the division through the chairman of his advisory committee.

Comprehensive Examinations — The comprehensive examination consists of two parts: a written examination and the oral defenses of a proposition. The written examination is scheduled for one full day and encompasses the entire field of the major. The oral examination on the proposition is directed primarily to the research topic submitted but may include relevant background material.

The proposition represents a thesis in miniature without laboratory work. With the aid and advice of his advisory committee the student selects a subject suitable for investigation, completes a literature survey, outlines the method of approach, and suggests possible results and conclusions. He is then required to defend his proposition by oral examination. The examination is conducted by the student's advisory committee and with other faculty members of the department in attendance.

Prior to the oral examination and at least one month before the scheduled date of the written comprehensive examination, the student must file with the chairman of his advisory committee three written copies of his proposition, presented in the form generally prescribed for a thesis. The oral defense of the proposition is presented after the written comprehensive examination, and permission to take the oral examination is contingent on first passing the written test.

The request to take both qualifying and comprehensive examinations must be initiated by the student. The request is made to the advisory committee,

and the chairman of that committee then submits a written recommendation to the division chairman that the examination be given. The examination schedule is published well in advance of the date set, and the student must file the request with his advisory committee at least one month before the scheduled date. The deadline normally is 5 P.M., May 1, for the June examinations and 5 P.M. on the last day of classes in the second semester for the September examinations.

Thesis Examination — Upon completion of his doctoral research, the candidate must present himself for oral examination on his thesis. Permission to take this examination must be sought through the advisory committee chairman to the division chairman and is granted only after all candidacy requirements have been met and the comprehensive examinations passed.

Language Examinations — A candidate for the doctorate must demonstrate by examination ability to read technical literature in two foreign languages. One foreign language must be German. The second language is generally French or Russian. Proficiency in English is a requirement for foreign students, and the department reserves the right to establish this proficiency by examination if such action is indicated.

Language examinations are scheduled in November and in March. The student must present himself for examination in at least one language at each scheduled examination period until the complete language requirement has been fulfilled.

Course Offerings and Distribution

As a basis for the candidacy examinations the following core of subjects is recommended for the first-year students in the doctoral program:

CH	423-424*	Advanced Organic Chemistry	(3-0)(3-0)6
CH	431-432*	Advanced Physical Chemistry	(3-0)(3-0)6
CH	443-444*	Advanced Inorganic Chemistry	(3-0)(3-0)6
CH	564	Organic Qualitative Analysis	(1-6)3

If results from the diagnostic examinations indicate adequate background in any of the above subjects, substitution by a more advanced subject in the 500 series is recommended. Full graduate credit is allowed in the 400 subjects listed above, but credit is not allowed in advanced 400 subjects representing the field of the major, even though these may be recommended. Additional subjects in chemistry or in the field of the minor may be taken in the first year if desired, provided the prerequisites are met.

In the second year, subjects supporting concentration in specific fields are available as follows:

Organic Chemistry

CH	513	Chemical Applications of Spectroscopy and Spectrophotometry	(3-0)3
CH	514	Physicochemical Methods	(2-0)2

CH	521-522	Physical Organic Chemistry	(3-0)(3-0)6
CH	527-528	Stereochemistry	(3-0)(3-0)6
CH	553	Organic Chemistry of Macromolecules	(3-0)3
CH	554	Stereochemistry of Macromolecules	(3-0)3
CH	561-562	Advanced Organic Synthesis	(3-0)(3-0)6
CH	565	Metal-Organic Compounds	(3-0)3
CH	566	Heterocyclic Chemistry	(3-0)3

The core of subjects recommended for majors in organic chemistry includes CH 521-522, CH 527-528, and CH 561-562. Majors in organic chemistry must also meet a requirement in physical chemistry comprising the course sequence CH 539-540.

Physical Chemistry

CH	531-532	Chemical Thermodynamics	(3-0)(3-0)6
CH	533	Statistical Mechanics for Chemists	(3-0)3
CH	534	Quantum Mechanics for Chemists	(3-0)3
CH	535-536	Advanced Topics in Physical Chemistry	(3-0)(3-0)6
CH	538	Rheology	(3-0)3
CH	539	Theoretical Chemistry	(3-0)3
CH	540	Chemical Kinetics	(3-0)3

Polymer Science

CH	503-504	Chemistry of High Polymers	(3-0)(3-0)6
CH	505-506	Techniques of Polymer Chemistry	(0-4)(0-4)2
CH	521-522	Physical Organic Chemistry	(3-0)(3-0)6
CH	527-528	Stereochemistry	(3-0)(3-0)6
CH	539	Theoretical Chemistry	(3-0)3
CH	540	Chemical Kinetics	(3-0)3
CH	551-552	Physical Chemistry of Macromolecules	(3-0)(3-0)6
CH	553	Organic Chemistry of Macromolecules	(3-0)3
CH	554	Stereochemistry of Macromolecules	(3-0)3
CH	555	Polymer Physics	(3-0)3
CH	556	Physical Chemistry of Surfaces	(3-0)3

The program of Polymer Science is intended to provide a knowledge of the special physical and chemical behavior of macromolecular substances to the student who has a strong background in organic and physical chemistry. Recommended electives include CH 533, Statistical Mechanics; CH 538, Rhelogy; and MA 433* or 434,* Matrix Algebra.

Chemistry Seminar

During each year of residence the student is required to attend and to participate in CH 507-508, Chemistry Seminar, (1-0)(1-0)2.

Majors and Minors

Students may major in Organic Chemistry, Physical Chemistry, or Polymer Science. The prospective candidate, moreover, is expected to supplement his training in the major field of interest by electing a minor. The minor should represent a minimum of 12 credits and may be divided between two fields of study. The minor program may be selected from chemistry subjects outside the major field of interest, as well as from approved advance subjects in physics, mathematics, or engineering.

REQUIREMENTS FOR PH.D. DEGREE IN CHEMISTRY

Term of Residence

Only work done during the regular academic year from September to June is counted toward residence credit. A minimum of one full academic year of study in residence is required of all candidates. A full year constitutes not less than 36 credit hours of work. Semesters in residence should be consecutive if possible.

All requirements for the doctorate must be completed within seven years after the student's entrance and within four years after admission to candidacy. Extension of time beyond this limit may be granted only with the joint approval of the student's advisory committee, his department head, his division chairman, and the Director of the Graduate School.

Candidacy for the Doctorate in Chemistry

To be admitted to candidacy for the doctorate, a student must:

1. Complete the first year's core of advanced subjects in physical chemistry, organic chemistry, inorganic chemistry, and physicochemical methods and have a satisfactory record in undergraduate training, graduate seminar, and collateral reading.
2. Pass the qualifying examinations which test his general knowledge. One day each is devoted to an examination in the following areas: organic chemistry, physical chemistry, and combined inorganic-analytical chemistry.
3. Fulfill the language requirements.
4. Secure the approval of his advisory committee and the division chairman.

When these requirements have been fulfilled, the division chairman notifies the Director of the Graduate School in writing and recommends that the student be placed on the list of candidates for the Ph.D. degree. Admission to candidacy in no way guarantees the granting of the degree.

Requirements for Graduation

To be recommended for the Doctor of Philosophy degree in Chemistry a candidate must:

1. Satisfy the residence requirements.
2. Pursue an approved program of study that includes the satisfactory completion of at least 90 credit hours beyond the bachelor's degree, or equivalent. At least half of these credits must be in formal course work exclusive of seminars or thesis.
3. Maintain at least a B— average in all work in formal subjects offered for the degree. The lowest grade acceptable for doctoral credit is C—. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work but which are taken during his enrollment as a graduate student must be passed with a grade of at least C—; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.
4. Demonstrate satisfactory reading ability in German and one other language (preferably French or Russian). Foreign students may under certain circumstances substitute their native tongue for one of these languages. Both language examinations must be passed prior to advancement to candidacy and before extensive work on the thesis is begun.
5. Pass the qualifying examinations for candidacy.
6. Pass the major examinations in the field of concentration. These examinations primarily test the student's knowledge in his special field of concentration and draw heavily on knowledge gained during his second full year of study in that particular area. They are given only when substantially all of the formal course work has been completed, normally at the end of the second full year (fourth semester). The major examination is in two parts. The first part is written and extends over a period of one day. It tests the student's broad knowledge in his specific field. The second part of the major examination is oral and tests the student's aptitude for research and his ability to organize and to develop a research problem. The examination takes the form of the defense of a proposition. The student selects a problem with the approval of his advisory committee.
7. Complete a satisfactory thesis. The doctoral thesis is designed to permit the student to demonstrate his ability to conduct original and independent research work. Results of the thesis investigation should constitute a definite contribution to knowledge in the field of specialization and should be suitable for publication. The field of the thesis investigation should be selected as soon as possible after admission to the graduate program, and the subject of the thesis must be approved by the advisory committee. As soon as the subject has been selected,

the student must make his choice known to the department head, who in turn notifies the Graduate School so that the list of theses in progress may be kept current. The thesis subject must be filed not later than two weeks after the student has been admitted to candidacy. The thesis normally constitutes about half of the total credit requirement and, as a rule, requires three to four semesters of full-time work.

8. Pass a thesis examination. This is an oral defense of the student's thesis before the faculty of the Department of Chemistry.

9. Satisfy all requirements as to tuition and fees.

PH.D. PROGRAM IN PHYSICS

A research program in both theoretical and experimental physics leading to the degree of Doctor of Philosophy in Physics is offered in the following fields: Theoretical Physics, Solid-State Physics, Nuclear Physics, Electron Device Physics, and Atomic and Hyperfine Spectroscopy.

Objectives

The doctoral program in Physics is designed **(a)** to provide the student with a thorough training in classical and modern physics and **(b)** to advance the student to the level where he can successfully carry out independent experimental and theoretical work in problems of modern-day physics.

Plan of Program

An incoming graduate student is assumed to possess a sound background in intermediate-level mechanics, electricity and magnetism, statistical mechanics, thermodynamics, and modern physics. Accordingly, a typical graduate curriculum would be drawn from the following subjects:

First Year

MA	505-506*	Mathematical Methods of Physics	(3-0)(3-0)6
PH	471-472*	Solid-State Physics	(3-0)(3-0)6
PH	511*	Classical Mechanics	(3-0)3
PH	515-516	Quantum Mechanics	(3-0)(3-0)6
PH	521*	Statistical Mechanics	(3-0)3
PH	557-558*	Electricity and Magnetism	(3-0)(3-0)6

Second Year

PH	537	Group Theory	(3-0)3
PH	561	Nuclear Physics	(3-0)3
PH	575-576	Problems in Solid-State Physics	(3-0)(3-3)7
PH	593-594	Graduate Laboratory	

Third and Fourth Years

PH	517	Advanced Quantum Mechanics	(3-0)3
PH	519	Theory of Weak Interactions	(3-0)3
PH	555	Plasma Physics	(3-0)3
PH	583-584	General Theory of Relativity	(3-0)(3-0)6
PH	601-606	Special Problems	
PH	701-706	Doctoral Thesis	

Subjects marked with an asterisk are ordinarily required and may be waived for the incoming student only at the discretion of the department head. A student whose background is deficient in one or more areas may require subjects in these areas his first year. However, such subjects may not be taken for graduate credit toward the Ph.D degree.

Examinations for Doctoral Students in Physics

Preliminary Examination — Prior to the second semester of his second year the candidate must have achieved a satisfactory score, to be determined by the graduate faculty, in the Graduate Record Examination in Physics. The candidate has three chances to achieve this score; however, he must notify the department head prior to taking the examination.

Ph.D. Qualifying Examination — Prior to the second semester of his third year the student must have taken the Ph.D. Qualifying Examination. The examination itself consists of both a written and oral part, given, if the need demands, three times a year — in September, January, and June. The written examination consists of two four-hour examinations, given on successive days, testing the student's understanding of graduate-level material in the following subjects: Classical Mechanics, Classical Electricity and Magnetism (including Special Relativity), Quantum Mechanics (on the level of Schiff), Statistical Mechanics, Thermodynamics, Nuclear and Atomic Physics, and Mathematical Methods of Physics. The oral examination, given by the staff shortly thereafter, is directed by a committee selected from the faculty.

If the candidate fails on his first attempt, he must repeat the examination no later than September of his fourth year. If he fails a second time, he may no longer be considered a candidate.

Successful completion of the qualifying examination requires passing grades in both oral and written parts.

Final Examination — The candidate must pass a final oral examination administered by his thesis committee and other faculty members. This examination consists mainly of a defense of the results of his thesis but may also include background and other material at the discretion of the committee.

Requirements for Graduation

Requirements for the degree of Ph.D. in Physics are as follows:

1. **Residency** — A minimum of two years of full-time residency (18 credits per year). However, in the case of a candidate who enters the Institute with a master's degree in Physics, the requirement is two years **or** one year subsequent to achieving a satisfactory score in the Ph.D. qualifying examination. In addition, no degree will be awarded to a candidate in less than three years if he enters with a bachelor's degree, or in less than two years if he enters with a master's degree.

2. **Grade Average** — A grade average of at least B— must be maintained in all graduate subjects offered for the degree. The lowest grade acceptable for doctoral credit is C—.

3. **Foreign Language** — The candidate must demonstrate to the satisfaction of the graduate faculty his reading proficiency in two of the following three languages: French, German, Russian.

4. **Examinations** — The candidate must pass the preliminary, qualifying, and final examinations.

5. **Thesis** — The candidate must conduct original research leading to a thesis, indicating his ability to carry out independent research on the doctoral level. This thesis must be unanimously approved by a thesis committee of three members of the faculty. The candidate's thesis adviser is a member of this committee.

6. **Tuition and Fees** — All tuition and fee requirements must be satisfied.

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Further information concerning these subjects may be obtained by writing to the following sources:

Admissions	Director of Admissions
Scholarship aid	Dean of Students
Official transcripts	Registrar
Graduate studies	Director of Graduate School
Summer school	Director of Summer School
Evening study program . .	Director of the Evening Division
Alumni affairs	Alumni Office
Graduate placement . . .	Placement Director
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Lowell, Massachusetts 01854

Established 1895

Operated by the Commonwealth of Massachusetts

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Evening programs leading to A.B.M., A.A.S., A.S., and A.Eng. degrees

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Tuition: $200 for U. S. citizens who are residents of Massachusetts

$600 for all others

L.T.I. Research Foundation conducts research and development work for government and industry.

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Telephone number: 454-7811 (Area Code 617)

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ACADEMIC CALENDAR, 1966-1967

September 12, Monday	Registration of graduate students begins. Freshman Orientation Week begins.
September 15, Thursday	Registration of seniors and juniors.
September 16, Friday	Registration of sophomores.
September 19, Monday	Classes begin.
September 26, Monday	Last day to register for new classes.
October 4, Tuesday	No classes after 1 p.m. Field Day activities.
October 12, Wednesday	Columbus Day. Institute closed.
October 19, Wednesday	Last day to drop classes without penalty.
November 11, Friday	Veterans Day. Institute closed.
November 23, Wednesday, 1 p.m.	Thanksgiving recess begins.
November 28, Monday	Classes resume.
December 16, Friday, 6 p.m.	Christmas recess begins.
January 3, Tuesday	Classes resume.
January 14, Saturday, 8 a.m.	Examinations begin.
January 23, Monday	End of first semester.
January 31, Tuesday	Registration of freshmen.
February 2, Thursday	Registration of juniors, seniors, and graduate students.
February 3, Friday	Registration of sophomores.
February 6, Monday	Classes begin.
February 10, Friday	Last day to register for new classes.
February 22, Wednesday	Washington's Birthday. Institute closed.
March 7, Tuesday	Last day to drop classes without penalty.
March 17, Friday, 6 p.m.	Spring recess begins.
March 27, Monday	Classes resume.
April 19, Wednesday	Patriots Day. Institute closed.
May 9, Tuesday	No classes. Upstream Day.
May 15, Monday	Last day for submitting graduate theses.
May 27, Saturday, 8 a.m.	Second-semester examinations begin.
June 5, Monday	End of second semester.
June 11, Sunday	Commencement.

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Carl A. Stevens, B.S., M.S. (Tufts University), Sc.M. (Brown University), Ph.D. (Boston University), P.E. (Massachusetts), Prof., in charge of Department of Electrical Engineering

Albert Stone, Jr., B.A., LL.B. (University of Texas), M.A. (University of Houston), Ph.D. (Harvard University), Assoc. Prof., Languages and Literature

James E. Stone, B.S. (Springfield College), Instr., Physical Education

Arthur D. Talkington, B.S. (University of Chicago), M.A. (University of Missouri), Asst. Prof., Mathematics

Virginia S. Taylor, B.S. (Syracuse University), M.A. (Western Michigan University), Asst. Prof., Mathematics

Major Nicholas Theochares, USAF, B.S. (Springfield College), Asst. Prof., Aerospace Studies

Henry E. Thomas, B.T.E. (Lowell Technological Institute), P.E. (Massachusetts), Prof., Plastics Technology

Marco Tomaselli, Ph.D. (Torino University, Italy), Instr., Physics

George J. Toscano, B.S., M.B.A. (Northeastern University), C.P.A., Assoc. Prof., Economics and Management

Col. Charles L. Vacanti, USAF, B.S. (University of Nebraska), M.A. (University of New Mexico), Prof., in charge of Department of Aerospace Studies

David P. Wade, B.S. (Lowell Technological Institute), M.S. (Northeastern University), Asst. Prof., Electrical Engineering

David A. Wagenknecht, B.A., M.A. (Boston University), Instr., Languages and Literature

Francis R. Walsh, B.S., M.A. (Boston University), Asst. Prof., Social Sciences

Tso-Chou Wang, Dip. in Eng., D. Eng. (Technische Hochschule, Germany), Assoc Prof., Mechanical and Textile Engineering

Joseph W. Waterman, B.S. (University of Vermont), M.B.A. (Boston University), Asst. Prof., Social Sciences

Arthur C. Watterson, Jr., B.S. (Geneva College), Ph.D. (Brown University), Asst. Prof., Chemistry

Louis I. Weiner, B.S. (Temple University), M.S. (Lowell Technological Institute), Visiting Professor, Textile Technology

Robert J. Whelan, B.S. (Boston College), M.A. (Catholic University of America), Asst. Prof., Languages and Literature

Roger E. Wiehe, B.A. (Yale University), M.A. (University of Illinois), Ph.D. (Columbia University), Assoc. Prof., Languages and Literature

Martin Wilner, B.S. (Rensselaer Polytechnic Institute), M.S. (Yale University), Ph.D. (Massachusetts Institute of Technology), Asst. Prof., Physics

Albert T. Woidzik, B.S. (Lowell Technological Institute), P.E. (Massachusetts), Assoc. Prof., Textile Technology (on sabbatical leave of absence)

Francis T. Worrell, B.S. (University of Michigan), M.S., Ph.D. (University of Pittsburgh), Prof., Physics

Waldo W. Yarnall, B.S. (University of Vermont), Director of Athletics

Professors Emeriti

Hermann H. Bachmann
Horton Brown, B.S.
William G. Chace, Ph.B., M.S.
Harold C. Chapin, A.B., A.M., Ph.D.
Lester H. Cushing, A.B., Ed.M.
James G. Dow, A.B.
Elmer E. Fickett, B.S., Sc.D.
C. Leonard Glen
Martin J. Hoellrich
Nathaniel E. Jones
James H. Kennedy, Jr., B.T.E., M.S.
Gilbert R. Merrill, B.T.E.
John L. Merrill, B.T.E.
A. Edwin Wells, B.T.E., M.Ed., P.E.

ADMINISTRATIVE ASSIGNMENTS

Admissions Office

Maurice W. Harrison, B.T.E., Director of Admissions
Mary E. Perkins, Secretary

Assistant to the President's Office

Kleonike J. Bentas, Secretary

Buildings and Power

George F. Abodeely, LL.B., Administrator
Ralph E. Frost, Chief Engineer
Joseph A. Nerney, Maintenance Foreman

Bursar's Office

Richard F. Connolly, Business Office Manager
Wilfrid J. Brodeur, Bursar
Irene D. Burns, Clerk
Gerald F. Cronin, Administrative Assistant
Diane M. Faulkner, Clerk
Patricia J. Gallagher, Bookkeeper
Charles F. Johnson, Property Officer
John L. Sayer, Bookkeeper
Mary C. Sullivan, Clerk
Helen Shanahan, Clerk

Data Processing

William J. Keenan, Director

Dean of Faculty's Office

Theresa D. Leblanc, Secreatry

Dean of Students' Office

Barbara Jean Maccaron, Secretary

Division of Chemistry and Applied Chemistry

Harriet E. Burns, Secretary
Mona M. Davis, Secretary
Frank B. Ridge, Chemical Storekeeper

Division of Evening Studies

Caroline C. Dimitriou, Secretary
Ann V. Lenihan, Clerk
Aristomenes G. Panos, B.S. in B.A., Recorder

Division of General Studies

Joanne M. Poitras, Secretary

Division of Physics and Engineering Science

Joan Cinq-Mars, B.S., Secretary
Eleanor M. McKenna, Secretary
Leo F. Patenaude, Electronics Equipment Supervisor

Financial Aid

Walter A. Costello, B.S., Officer

Graduate School Office

Anita B. Lacie, Secretary

Guidance

John J. MacLaughlan, Ph.B., A.M., Director

Health Services

Arlene D. Gordon, R.N., In charge
Janet E. Connors, R.N.

In-Service Training Program

John J. Delmore, Administrative Assistant

Libraries

Howard K. Moore, A.B., A.M., Ph.D., Director
Joseph V. Kopycinski, B.S., M.S., M.S. in Library Science, Librarian
Charles F. Donaldson, Library Assistant
Ruth B. Fitzgerald, Senior Library Assistant
Mary P. Frascarelli, Library Assistant
Eleanor T. Lessard, Library Assistant
Vera Boyd Meehan, B.S., Senior Library Assistant
Madeline Owens, Library Assistant
Ann V. Pendergast, Library Assistant
June E. Traverse, Library Assistant

Placement Office

James A. Brennan, Director

President's Office

Elizabeth P. Kennedy, C.P.S., Secretary
Mary E. Perkins, Secretary

Receptionist

Lorraine I. LeDoux

Registrar's Office

Frank J. Duggan, Jr., A.B., Registrar
Mary P. Kloppenburg, Clerk
Nora M. MacBrayne, Secretary
Mabel M. Murphy, Clerk
Catherine P. Ouellette, Clerk

Special Services

Anita B. Lacie, Secretary

Summer School

Ernest P. James, B.T.C., M.S., Director

GENERAL INFORMATION

History

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry.

In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, mathematics, nuclear science, nuclear engineering, industrial management, business administration and meteorology.

In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to the Lowell Technological Institute. The Institute grants Bachelor of Business Administration, Bachelor of Science, Master of Science, and Doctor of Philosophy degrees.

Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

Accreditation

The Institute is a member of the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends accreditation to the curricula in electrical, mechanical, and textile engineering, and the chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races

and religions are represented in the enrollment. Although the majority of its students are men, the Institute is co-educational.

Campus

The Institute is located 25 miles north of Boston in Lowell, Massachusetts, a city of nearly 100,000, long famous as a textile center and more recently noted for its increasingly diversified industries. The 25-acre campus, situated on the Merrimack River, includes eleven main buildings, among them the library, an auditorium-administration building, six classroom-laboratory buildings, two residence halls, and a power plant. A $4,500,000 nuclear center and a $2,120,000 physical education building are under way.

Alumni Memorial Library

The library, dedicated to alumni of the Institute who served in World Wars I and II and the Korean conflict, was erected in 1951 by the Alumni Association through contributions from alumni and friends. Besides a book stack capacity of 80,000 volumes, it contains student activity offices and alumni headquarters and houses one of the world's most complete collections of textile books as well as numerous special collections in the fields of paper, leather, and plastics. It also serves as a depository for U. S. government publications and is available to industrial concerns through its Industrial Corporate Membership program.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than $10,000,000. It includes such varied apparatus as an electron microscope, analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, plastics, leather, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Admissions Office has received senior grades for this period. The responsibility of having these marks forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure not less than 12 months in advance of the expected date of enrollment.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Director of Admissions, Lowell Technological Institute, Lowell, Mass. 01854.

Applications for admission must be received by the Institute on or before June 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is in need of financial assistance may request an application for a loan under the National Education Defense Act or an application for scholarship aid AFTER he has been accepted for admission to Lowell Technological Institute.

Application Procedure

A candidate for admission should:

1. Complete the first two pages of the admission application form.

2. Attach a certified check or money order in payment of the application fee of $10 and is not refundable.

3. Submit the entire application form to the office of his secondary-school principal, with a request that the office fill out

pages 3 and 4 and mail the completed application directly to the Director of Admissions.

4. Request transcripts be sent to Lowell Technological Institute from any college, preparatory school, or institution of learning beyond secondary school that he has attended.

5. Make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test which is required of ALL applicants for admission to the freshman class at the Institute. The applicant must take the Scholastic Aptitude Test during his senior year in secondary school or thereafter. Letters, telephone calls, etc., will not be accepted in place of the official score card.

Applicants for admission who are in the upper 20% of their high-school class scholastically may be admitted by the Director of Admissions prior to their completion of the CEEB examinations. This examination, however, must be completed during the senior year and the results forwarded to Lowell Technological Institute before final acceptance is granted.

6. Undergo a complete health examination by his family physician. The physician must return to the Student Health Services on a form provided by the Institute, a certificate of good health, indicating the date of the examination. Health certificates are not sent to the applicant until he has been finally accepted by the Institute.

7. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of his place of residence. This certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

8. Upon receipt of his letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll.

Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition.

If an applicant plans to attend the Institute, after receiving his final acceptance letter he should instruct his secondary school to send a transcript of his final grades to the Admissions Office after his graduation.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus days. Personnel from the Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. This year they will be held on October 21, 1966, and on Feb-

ruary 24, 1967 and April 21, 1967, commencing at 10:30 a.m. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Entrance Certificate Board, the Regents of the State of New York, or a board of equal standing.

2. For all courses except Business Administration a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiency in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration a candidate must have completed 16 units of approved high-school work:

English	4 units
mathematics	2 units
American history and social studies	2 units
laboratory science	1 unit
foreign language	2 units
electives	5 units

as well as the Scholastic Aptitude Test. He should also indicate

his choice of this program on the top right-hand corner of the formal application form.

Admission with Advanced Standing

Transfer students must file a formal application for admission to the Institute and must answer "yes" to question 6(b) on page 1 of the application. This must be received prior to April 1 of the year in which the student wishes to matriculate.

Transfer credit is given for courses satisfactorily completed with a grade of C or better which are the equivalent in quality and scope of those given at the Institute. Final decision on transfer credit rests with the appropriate division chairman and the Director of Admissions.

Transfer students who have not taken the Scholastic Aptitude Test of the College Entrance Examination Board for matriculation at their previous college may be required to do so. It is the responsibility of the transfer student to ascertain from the Admissions Office the procedure to be followed prior to his acceptance.

Transfer credit for subjects taken prior to admission to the Institute will not be given any student after his matriculation.

Advanced Placement

Lowell Technological Institute subscribes to the program of the College Entrance Examination Board providing academic credit for students qualied for advanced standing. Those interested must take CEEB Advanced Placement Tests and have them submitted to Lowell Technological Institute for evaluation.

Students from Other Countries

All foreign applicants for whom English is a second language and who have been in the United States for less than two years must take an English proficiency test and have the results sent to the Director of Admissions prior to filing a formal application with the Institute. The test used by the Institute to determine English proficiency is TOEFL (Test of English as a Foreign Language). Students should arrange to take this examinaation by writing to the Educational Testing Service in Princeton, New Jersey, 08540, U. S. A. and, as stated above, request the results be sent to Lowell Technological Institute.

The Institute accepts every year foreign applicants in numbers up to 5% of each entering class. In all other respects, the admission procedure for foreign students is the same as that required of U. S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, in ENGLISH,

and not less than twelve months in advance of the expected date of enrollment. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U. S. students.

To facilitate their adjustment to campus life, all freshman male students from other countries are required to live in the Institute's residence halls and are assigned to rooms shared by U. S. students. Students must supply their own towels, sheets, pillows and pillowcases, and blankets or may subscribe to a laundry service. Bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.

STUDENT HOUSING AND SERVICES

Residence Halls

All male freshmen not living at home are required to live in the residence halls on campus unless they are excused in writing by the Dean of Students. Excuses are reviewed at the beginning of each semester and may be cancelled, should conditions warrant.

Application for permission to occupy other living quarters must be made by letter to the Office of the Dean of Students.

Permission is accorded in cases where the student lives a reasonable distance from the Institute, where financial hardship would be involved through living in a residence hall.

Although rooms are furnished by the Institute, students must take care of them. Each student must supply his own sheets, pillow and pillowcases, blankets, towels, and personal linens or may subscribe to the laundry service provided to all resident students at cost. Each occupant of a room is responsible for damage which may result to furniture or equipment.

Room assignments in residence halls are made for the full academic year. A change of room is not permitted except in rare instances and may be accomplished only after formal application for the change is approved by the Dean of Students.

Rental charge for each residence room is made for the academic year. While the charge covers occupancy only during periods when the Institute is in regular session, it may, at the discretion of the Institute, be extended to include vacation periods.

Room assignments are made as equitably as possible and in the order that applications are received. The Dean of Students Office supplies a list of rooming houses where students may reside who are unable to be placed in residence halls.

Students are cautioned to make no legal agreements nor sign residence leases with persons outside the Institute.

Dining Hall

A cafeteria and a snack bar are available in the residence halls, but use of campus dining facilities is not compulsory.

Health Service

The dispensary is in the charge of two registered nurses for eight hours each school day. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to

take in case of illness. Medical services are available to students 24 hours daily. There are three excellent modern hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

If a student requires emergency surgical treatment, every effort is made to communicate with his parent or guardian. Failing this, such action is taken as appears to be necessary in the interest of the student.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance also is available, on a voluntary basis, through the Office of the Dean of Students.

Guidance

The guidance program, under the supervision of the Dean of Students Office, starts with the admissions procedure and continues throughout the freshman year. During Orientation Week, the freshman attends a series of lectures whose purpose is to help him in his adjustment to college requirements.

Freshmen should contact their instructors for academic problems and, if necessary, a referral may be made to the Director of Guidance for further assistance. Personal difficulties such as financial or similar problems should be brought directly to the Guidance Office. Due to the large numbers of students each year, it is impossible to call in all students. Responsibility for interviews must rest with the student when he feels that he needs advice or clarification.

Other phases of the guidance program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions. In the second semester of the freshman year a series of lectures is offered to help the student become aware of the curricula at the Institute and determine what course he should elect for the next three years.

Guidance in the upper classes is generally conducted in scholastic matters by the Head of the department concerned and in personal problems by the Director of Guidance.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A STUDENT MAY BE DROPPED FROM THE ROLLS WHENEVER IT IS CONSIDERED IN THE BEST INTERESTS OF THE INSTITUTE.

In some laboratories students are required by state law to wear safety eyeglasses, which may be purchased at the LTI Bookstore. The instructor in each class requiring the use of such eyeglasses will inform the students of the necessity of using them.

Disciplinary Action

Disciplinary action may be in the form of censure, restriction, suspension, or dismissal, according to the measure of an offense. Whenever such action is taken, notation of the penalty is made a part of the permanent record of the student.

Attendance

All students must attend all classes, although a limited number of absences is permitted. Attendance is taken at all classes. Students charged with unexcused absences, particularly immediately before and after holiday and vacation periods, are subject to disciplinary action.

Academic Grades

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.30	(97-100)	C+	2.30	(77-79)
A	4.00	(93-96)	C	2.00	(73-76)
A—	3.70	(90-92)	C—	1.70	(70-72)
B+	3.30	(87-89)	D+	1.30	(67-69)
B	3.00	(83-86)	D	1.00	(63-66)
B—	2.70	(80-82)	D—	0.70	(60-62)

F 0 (below 60)

These point values, when multiplied by the credit hours

assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester is obtained in the same manner as the computation for the rating of a single semester.

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

In order that a student be classified "clear", he must achieve the following minimum semester ratings:

first-semester sophomore	1.45	first-semester junior	1.55
second-semester sophomore	1.50	second-semester junior	1.60
first-semester senior	1.65		

A student must achieve the following cumulative ratings:

beginning of sophomore year	1.40
beginning of junior year	1.50
beginning of senior year	1.60

Probation and Dismissal

A student is placed on probation when his semester rating is below 1.35. A student who fails to achieve the required cumulative rating shall be placed on probation. The probationary period covers the entire semester following the issuance of the semester or cumulative rating which placed the student on probation.

A student on probation may not represent the Institute in any public function or any extracurricular activity and may not hold any class office or other office during his term of probation. If a student receives a semester rating below 0.70, he is automatically dropped from the Institute without benefit of a probationary period. A student with a semester rating of less than 1.35 for two consecutive semesters is dropped from the Institute for at least one semester. If a student is dropped for either of the last two reasons, he MUST take subjects at some other college to prove himself before applying for readmission to LTI. These subjects are non-transferable, but rather prove the student's capability academically.

A student on academic probation will be dropped from the Institute for at least one semester if during his probationary semester he fails to achieve the required semester rating.

Requirements for Graduation

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula

with no substitutions for major subjects and no unremoved failures in a major subject.

2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors—graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors—graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors—graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION FEE **$10**

1. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days of the date upon which the applicant is accepted for admission. For Massachusetts residents this amounts to $50. This prepayment is forfeited if the student fails to register at the Institute. In rare instances, such as sickness which would prevent the applicant from enrolling, this rule may be waived by the Dean of Students.

TUITION

	(per year)
U. S. citizens who are residents of Massachusetts ..	**$200**
All others	**$600**

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

U. S. citizens who are residents of Mass.	**$10.00 per cr. hr.**
All others	**$30.00 per cr. hr.**

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.
2. The residence of a minor follows that of the parents, unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evidence of emancipation.
3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.
4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.
5. The residence of a wife follows that of the husband.
6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.
7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.
8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

Note: Wherever mentioned above, the word residence means legal domicile.

ROTC DEPOSIT **$25**

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the amount on deposit, he must pay the charges and make an additional deposit of $25.

ACTIVITY AND INSURANCE FUND **$49**

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

RESIDENCE HALLS

The residence hall charge is at the rate of $700 per room for the academic year, this sum to be divided equally among all occupants of the room (two to four students). One-half of the charge is payable by each occupant at the beginning of each semester.

LATE REGISTRATION FEE **$5**

A student who does not complete his registration (including the payment of all fees) by the close of the registration period must pay this additional fee.

AUDITING FEE .... **$5/credit hour**

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay $5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE **$15**

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap

and gown, invitations, printing, and any other expenses approved or directed by the President.

OFFICIAL TRANSCRIPT FEE $1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of $1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

Laboratory equipment may not be removed from the premises except by special permission.

REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks At least	But less than	Refund Rate
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over		None

SUMMARY OF EXPENSES PER YEAR

Tuition	
U. S. citizens who are residents of Massachusetts	**$200**
All others	**$600**
Residence halls	**$700 per room,** divided equally among occupants (2 to 4)
Student activity and insurance fund	**$ 49**
ROTC deposit	**$ 25**
Books, supplies, and related miscellaneous expenses (approximate)	**$100**

There is no set boarding fee, but a cafeteria is available for meals on a cash basis.

FINANCIAL AID

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time.

At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Director of Admissions before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Albany Felt Company Scholarship

One annual grant of $500 to a freshman entering the Institute is made by the Albany Felt Company. Each recipient is given an opportunity for summer employment at the company while in college.

Alumni Association Scholarships

The LTI Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is main-

tained. Funds for these scholarships are derived from the following sources:

Stephen E. Smith Scholastic Fund
James T. Smith Fund
Arthur A. Stewart Memorial Scholarship Fund
Warwick Chemical Foundation in memory of Walter Nowicki
New York Chapter, LTI Alumni Association

Berkshire Hathaway, Inc. Scholarships

A number of scholarships covering tuition and living expenses for four years are offered in Textile Engineering and Textile Technology by Berkshire Hathaway, Inc., Providence, R. I. Male employees and sons of employees only are eligible. Students interested should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence, R. I.

Russell L. Brown Scholarship, donated by Davis and Furber Machine Company

This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipened is $300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship

This $200 scholarship is awarded to the male student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship

This $250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships

The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is $200, and each is renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition

scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of $250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and the scholarships are renewable on the condition that satisfactory grades are maintained.

Paper Engineering Department Scholarships

Five scholarships, each amounting to $2000 over the four-year period, are available to incoming freshmen who plan to enroll in the Paper Engineering program. Scholarship holders receive annual stipends of $500 provided they maintain good academic standing.

Present contributors to this scholarship program include the following:

Bryon Weston—Crane and Company
Carter, Rice, Storrs & Bennett, Inc.
Crocker, Burbank & Co., Association
Dennison Manufacturing Company
Erving Paper Mills
Fraser Paper Ltd.
Hollingsworth & Vose
International Paper Company
Ludlow Corporation
Mohawk Paper Mills
Nashua Corporation
Oxford Paper Company
Paper Management Association,
Connecticut Valley Division
Riegel Paper Corporation
Tileston & Hollingsworth Company
Triangle Foundation
S. D. Warren Company

Sylvan I. Stroock Scholarship, donated by S. Stroock & Co., Inc.

A $500 scholarship is awarded each year on the basis of scholarship, financial need, leadership, and promise of success in textile fields from funds established by S. Stroock & Co., Inc.

Science Count-Down Scholarship

A one-year tuition scholarship is available annually to a student who has won first place in Science Count-down, the televised science quiz for Massachusetts eighth-grade pupils, co-sponsored by the Institute and WBZ-TV, the Westinghouse Broadcasting Company television station in Boston.

United Elastic Corporation Scholarships

Scholarships of $250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Mass., West Haven, Conn.; and Stuart, Va.

United States Rubber Company Foundation

This Foundation has established scholarships for students who have succesfully completed at least two years of college in which they have demonstrated leadership, capacity for higher education, and a recognition of its cultural and economic value. Applicants must be in need of financial assistance, and recipients assume a moral obligation to repay over a reasonable period at least 25% of the scholarship aid received.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, not to exceed $800, is available to an undergraduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

AVAILABLE TO UPPERCLASSMEN ONLY

AFROTC Financial Assistance Program

Scholarships are available to a limited number of selected cadets entering Aerospace Studies 300 in the Air Force ROTC four year program. This assistance covers full tuition costs, books, laboratory expenses and incidental fees. Scholarship cadets also receive $50 per month subsistence allowance, as opposed to the monthly $40 received by other cadets in the Professional Officer Course.

Allied Chemical Foundation Scholarships

Two grants of $750, given by the Allied Chemical Corporation, are awarded to worthy students majoring in Textile Chemistry or Textile Engineering.

A.S.T.M.E. Awards

Merrimack Valley Chapter 113, American Society of Tool and Manufacturing Engineers, awards $100 annually to a junior-class member in good standing of the Student Chapter on the basis of leadership, scholarship, need, and contribution to the Society. The A.S.T.M.E. Student Chapter presents the Prof. J. Arthur Ainsworth award of up to $100 annually to any chapter member in good standing on the same terms.

Boston Paper Trade Association Scholarships

Three scholarships, each for $150, are open to sophomores, juniors, and seniors enrolled in Paper Engineering who are residents of New England. Awards are based on scholarship and character.

Chemstrand Corporation Scholarship

A scholarship of $500 is available to a superior, deserving student enrolled in textiles. Donor is the Chemstrand Corporation.

DeBell-Richardson Scholarship

DeBell-Richardson, Inc., the D. & R. Pilot Plants, Inc., and John M. DeBell have established a scholarship for a student majoring in Plastics Technology. It is awarded on the basis of scholastic success, extracurricular activities, and financial need.

Dixie Cup Scholarship

The Dixie Cup Division of American Can Company of Easton Pa., has established a scholarship in the amount of $500

per year. Students majoring in Chemical Engineering, Electrical Engineering, Mechanical Engineering, Paper Engineering, or Plastics Technology are eligible to apply, and selection is based on scholastic achievement, financial need, and extracurricular participation. The Company provides summer employment for the student holding the scholarship.

Foster Grant Scholarship

The Foster Grant Company, Inc. of Leominster, Mass., makes available on a one-year basis a tuition scholarship to a deserving student in Plastics Technology who is a resident of Massachusetts. Preference is given to a sophomore living in the Leominster area; however, if there are no applicants from that area, another candidate may be chosen. Scholarship, personality, and over-all student contribution to extracurricular activities are the general criteria used in selecting the recipient.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of $75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

New England Paper Merchants Association Scholarship

A $100 scholarship is open to a sophomore, junior, or senior in Paper Engineering who is a resident of New England. It is awarded on the basis of scholarship and character.

NOPCO Chemical Company Scholarship

The NOPCO Chemical Company of Newark, N. J., has established two $250 scholarships open to students majoring in Chemical Engineering, Chemistry, Paper Engineering, Plastics Technology, or Textile Chemistry who have proved themselves scholastically and who are active in extracurricular programs.

Society of Plastics Engineers Scholarship

A scholarship is granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to an upperclassman majoring in Plastics Technology.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes, scholarships are awarded

annually and are renewable under the usual conditions. The scholarships cover tuition and books. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and leadership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

AVAILABLE TO GRADUATE STUDENTS ONLY

Fellowships for graduate students are listed and described in the Graduate School section of this catalogue.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of $10 per quarter the first year and $20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

Geigy Loans

Giegy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry or Paper Engineering. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

Federal Financial Aid Programs

Available to Undergraduate & Graduate Students.

National Defense Student Loan

The National Defense Education Act offers loans to needy students. Repayment begins one year after graduation, unless

military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3%, beginning with the first payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

College Work-Study Program

The Economic Opportunity Act of 1964 (P.L. 88-452) as amended by Economic Opportunity Act of 1965 (P.L. 89-253) and the Higher Education Act of 1965 (P.L. 89-329) Title I Part C established the College Work-Study Program to stimulate and promote the part time employment of students, particularly students from low income families who are in need of the earnings from such employment to pursue courses of study in institutions of higher education. At LTI the program is available to full time students in good standing at the undergraduate and graduate levels during the Fall and Spring semesters and during the Summer Session.

AWARDS

AVAILABLE TO UNDERGRADUATE STUDENTS ONLY

Educational Opportunity Grants

The Higher Education Act of 1965, Title IV, Part A (P.L. 89-329) affirms the policy of the United States to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in post-secondary and higher education. The Act initiates a program of educational opportunity grants through institutions of higher education, to assist in making available the benefits of higher education to qualified high school graduates of exceptional financial need, who for lack of financial means of their own, or of their families, would be unable to obtain such benefits without such aid.

American Association of Textile Chemists and Colorists Book Prize. This is awarded to the outstanding graduating senior in the Textile Chemistry course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemistry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

ASTME Award. The Merrimack Valley Chapter, American Society of Tool and Manufacturing Engineers awards $100 to a member of the Student Chapter of the ASTME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years at college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Ben Faneuil Award. An annual award of $100 is made by Mr. Ben Faneuil of The Chelsea Industries, Chelsea, Massachusetts, to the sophomore majoring in Plastics Technology with the highest cumulative average.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of $50 in memory of Professor Jacob K. Frederick to a freshman, based on scholastic achievement and extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of $250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, formerly of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of $100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New Eng-

land Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry or Textile Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in chemistry.

President's Medal. This award is made to the student who is graduated With Highest Honors for the most distinguished academic record in his class.

The Harry Riemer Honor Award. This award is made available through the Textile Veterans Association of New York in honor of Mr. Harry Riemer, one of the textile industry's foremost personalities in the trade publication field. The award, which consists of a $25.00 United States Savings Bond, is made to an outstanding textile graduate who has been active in extracurricular activities and who has maintained a high level of scholastic achievement.

Radio Station WLTI Award. The staff of the student-operated radio station WLTI awards a plaque annually to a member outstanding for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

OTHER ASSISTANCE FOR MASSACHUSETTS RESIDENTS ONLY

Board of Educational Assistance Scholarships

These scholarships for one-quarter, one-half, or full tuition are available both to freshmen and to upper classmen. For full information write to

Executive Secretary
Board of Educational Assistance
200 Newbury Street
Boston 16, Mass.

Higher Education Loan Plan

Under this HELP plan, students beyond the freshman year may obtain bank loans up to $500 a year upon especially favorable terms. More specific information is available from

Massachusetts Higher Education
Assistance Corporation
1137 Statler Building
Boston 16, Mass.

PLACEMENT

Industrial Training Program

The Placement Office with the assistance of industry endeavors to place qualified underclassmen during summer vacation periods in industries of particular interest to the individual. These training opportunities are open to all students who have completed their sophomore year, except those on scholastic or disciplinary probation.

Objectives of the undergraduate Industrial Training Program are to supply essential industrial experience to the undergraduate, to provide the experience in human engineering only obtained in industry, to enable industry to preview individual students, and to further the liaison between the Institute and industry.

Placement Service

The Placement Office maintains active contacts with many industrial firms throughout the country in each of the fields of concentration presented at the Institute. A complete file of opportunities and data on the various industries and companies is available in the Placement Office to members of the graduating class.

The office arranges for representatives from industrial firms to interview students on campus. In a series of seminars speakers outline the opportunities in particular industries and various positions within the companies.

The office also aids industry in the difficult task of locating experienced personnel and assists alumni to establish new connections. The Placement Office cannot give any graduate a guarantee of employment; however, practically all seniors are placed prior to Commencement every year. No official part-time placement program is in operation because of the heavy academic schedule.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Memorial Library, the Research Foundation, and the Summer School program, the college provides such special services to industry and to the community as the following:

Industrial seminars and conferences;

Guidance work in the high schools;

Technorama, science fair for area high schools;

Consultive opportunities with the faculty;

Collaboration with the Agency for International Development of the government in its foreign aid program;

Special radio and television programs, such as Science Count-Down on Boston station WBZ-TV.

For information relative to these programs, address the Coordinator of Special Services at the Institute.

SUMMER SESSION

The Summer Session is designed primarily to serve three principal areas of interest: Professional Advancement Courses for industrial personnel; Undergraduate Credit Courses for college students who require deficiency clearance or who seek advanced standing; and Precollege Refresher Courses for incoming freshmen at LTI.

The industry-sponsored professional advancement program comprises a series of specialized intensive, one-to three-week courses in leather, paper, and textiles. The two six-week undergraduate sessions stress fundamental credit offerings in college mathematics, physics, chemistry, English, economics, electronics, mechanical engineering, accounting, marketing, management, and social studies.

Precollege Refresher Courses

The Precollege Refresher Program is especially designed for prospective LTI students who require additional background to fulfill minimum entrance requirements. Students must first apply for fall admission; the Director of Admissions designates the course or courses required for coverage of minor deficiencies in the high-school background. Five-week, noncredit courses in basic mathematics, physics, chemistry, and English are offered in an Early Session and a Late Session to accommodate all freshman candidates.

For further information or a Summer Session Bulletin, write to the Director of Summer School.

DIVISION OF EVENING STUDIES

The Division of Evening Studies offers five-year associate degree courses in business management, chemistry, mathematics, and radiological health, and in the following technologies: electrical engineering, electronic engineering, industrial engineering, industrial engineering, mechanical engineering, and plastics engineering.

It also offers a program of individual subjects in mathematics, science, technology, engineering, and general studies. These subjects are designed to serve the needs of the community, particularly of those people engaged in industry who wish to further their education.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Division of Evening Studies also offers an In-Service Training Program in Civil Engineering Technology limited to employees of the Commonwealth of Massachusetts and to employees of cities and towns within the Commonwealth.

The Graduate School offers a program in the Division of Evening Studies which leads to the Master of Science degree on a part-time basis. The academic requirements for this program are identical with those of the day school. Graduate courses offered in the day or evening programs are interchangeable.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. Selected subjects are also offered in an 8-week summer program. For further information, write to the Director of the Evening School.

RESEARCH FOUNDATION

The Lowell Technological Institute Research Foundation is a nonprofit organization authorized under the laws of the Commonwealth of Massachusetts. It was established for the purpose of encouraging and administering research sponsored by industry and government at the Lowell Technological Institute.

Its research projects benefit the educational program of the Institute by enabling both faculty and students to keep abreast of current developments in their respective fields and to develop further their capabilities.

The scientists and engineers of the Foundation's permanent personnel, together with the faculty of the Institute, constitute a staff available for research, development, and testing in the fields of chemistry, electronics, engineering, leather, management, paper, plastics, and physics.

The Research Foundation has its own specialized laboratories and field stations where research ranging from chemical modification of textile fibers to studies of the ionosphere and thermal radiation is performed. The Foundation also uses in its programs the entire facilities of the Institute. These facilities not only include the usual research tools found in a university or industrial laboratory but also include, in the areas of leather, paper, plastics, and textiles, full-scale and pilot-plant equipment for specialized studies. It is probably the only research organization in the world having at its disposal fully equipped laboratories for processing all types of fibers by all the common manufacturing systems into a finished fabric.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, publishes the official alumni newsletter, and the alumni directory, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum and Evening Division senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of Directors to any person not an active member who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts or sciences.

Communications should be addressed to the Executive Secretary, Alumni Office, Lowell Technological Institute.

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four officers elected by the student body, the president of each undergraduate class, and one representative from each of the classes. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee.

Alpine Club

Composed of students interested in mountain climbing, skiing, and associated sports. Numerous weekend trips are scheduled throughout the year. Highlight of the club is the week-long skiing trip during the semester break.

Angel Flight

Angel Flight is the co-ed auxiliary to and is sponsored by the Vandenberg Air Squadron of the Arnold Air Society. It is primarily a service organization. Its objectives are to advance and promote interest in the Air Force, obtain information regarding military services, and aid the progress of the Arnold Air Society at the Institute.

Athletics

The Athletic Association promotes an extensive varsity and intramural sports program. Varsity sports are soccer, basketball, baseball, skiing, tennis, and golf, and competition is mainly with college teams in the northeast section of the country. Intramural sports competition among classes, residence hall students, and fraternities is carried on throughout the year. All students are members of the Association and receive free admission to all intercollegiate contests played at home.

Audio-Visual Society

Objectives of the Audio-Visual Society, composed of students and faculty members interested in this field, are to build and maintain a library of records, recorded tapes, and films, to record special events, and to present various types of audio-visual programs.

Auf Deutsch, Bitte

Informal German conversation marks all meetings of Auf Deutsch, Bitte whose purpose is to foster an understanding of the language, customs, and culture of the German people. Films, music, lectures, and personal anecdotes are featured, and coalition with German clubs of other universities is encouraged.

Band

Band membership is open to all students who possess musical training or wish to learn to play a band instrument. It provides music for AFROTC ceremonies and participates in various college and civic programs.

Barbell Club

This club promotes physical fitness through an intelligently operated weightlifting program.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshmen.

Dormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

Drill Teams

Two AFROTC drill teams, armed and unarmed, are open to all cadets who desire to become proficient in precision drill. Exhibitions are presented at various functions throughout the academic year. The teams compete in the annual spring New York-New England College Drill Meet.

Duplicate Bridge League

Open to students and faculty members, the league conducts ten or more playing sessions each year to determine the cham-

pion team. Student members also participate in the annual national Intercollegiate Duplicate Bridge Tournament.

Eta Kappa Nu

To be eligible for membership in this scholastic honor society, one must be an Electrical Engineering major who has participated in campus activities and is of exemplary character. Juniors must be in the upper quarter of their class, and seniors must be in the upper third of their class. The purpose of the organization is to provide a closer union for students majoring in Electrical Engineering who have achieved high scholastic standing, demonstrated leadership in campus activities, and possess outstanding character.

Fraternities

There are five fraternities—Delta Kappa Phi, Omicron Pi, Phi Gamma Psi, Pi Lambda Phi, and Sigma Phi Omicron—of which four have their own houses. All provide social life off campus and two are national fraternity affiliates. The Interfraternity Council fosters the common interests of the five and sponsors interfraternity social and athletic events.

Hockey Club

This organization operates under the supervision of a faculty coach.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Latin-American Society

This organization unites students of Latin-American origin in a cultural and social program.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the mili-

tary profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units.

Pickout

The Pickout is the college yearbook. Its staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

- American Chemical Society, Student Chapter
- American Institute of Physics, Student Section
- American Association for Textile Technology, Student Chapter
- American Society of Mechanical Engineers, Student Chapter
- American Society of Tool and Manufacturing Engineers, Student Chapter
- Chemical Engineering Society
- Industrial Management Society
- Institute of Electrical and Electronics Engineers, Student Chapter
- Nuclear Engineering Society
- Paper Engineering Society
- Society for Advancement of Management, Student Chapter
- Society of Plastics Engineers, Student Chapter

Radio Station

WLTI is an all-student enterprise built and maintained by members of the LTI Broadcasting Society. Programs are transmitted by carrier current from the studio to the various campus buildings. By selling air time to local merchants, the station is self-supporting. Its members learn business practices as well as broadcasting and other radio techniques.

Religious Groups

Hillel. The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are

presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship. Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Club. Through the combined efforts of the spiritual advisors and many local friends, the Newman Club now has a Newman Center located at 52 Colonial Avenue (in the immediate vicinity of the campus). A student lounge with a library for study and a rumpus room with piano and Hi Fi system are available for student recreation. The center is open to all students of LTI, Lowell State College, and Lowell General Hospital School of Nursing from 10:00 a.m. to 1:00 a.m., Monday through Friday. Discussion groups and meetings with the Chaplains are in progress weekly, and all students are urged to visit and participate in the many programs now offered at the Newman Center.

Phanar Club. This is composed of Greek Orthodox students from Lowell State College and LTI.

Rowing Club

The LTI Rowing Club introduces LTI students to the techniques, training, and physical fitness required for competitive crew. Full fall and spring schedules provide races against schools, clubs, and colleges under the auspices of both The National Association of Amateur Oarsmen and The New England Amateur Rowing Association. Full coaching is provided for newcomers to the sport.

Skindiving Club

Non-divers are taught the safety measures involved by experienced divers who also skindive as a group.

Sorority

Phi Sigma Rho, the campus sorority, provides a center for the social life and association of the young women enrolled at the Institute.

Sports Car Club

This club promotes the safe, courteous, efficient, and skillful operation of sports cars on the highway and is a source of information for members.

Swim Club

This club operates under faculty supervision.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

TOC

The Tech Orientation Committee has as its special function the introduction of the new student to college life. TOC plans a month-long series of activities for entering freshmen during the orientation period to enable them to meet one another and to realize their responsibilities to their college.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students. The bi-monthly publication offers excellent journalistic and business experience to those who work on its staff.

Track Club

Students pursue this sport under faculty supervision.

Vandenberg Air Squadron of the Arnold Air Society.

The Vandenberg Air Squadron, a chapter of the national Arnold Air Society, unites selected Professional Officer Course AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs and aerospace exhibits during the year. The Military Weekend, annual highlight of its program, features a colorful drill ceremony and is climaxed by the formal Military Ball at which new members are accepted into the society.

Varsity, Club

The Varsity Club is composed of students who have earned letters in the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose is to give academic help to athletes and to foster a lasting friendship among the men participating in athletics.

Graduate Club

An organization to promote interdisciplinary understanding and provide a social program for Graduate students and Graduate faculty of LTI.

UNDERGRADUATE PROGRAMS

Sixteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science except the Business Administration program which leads to the Bachelor of Business Administration degree. These fields are:

Business Administration	Nuclear Engineering
Chemical Engineering	Nuclear Science
Chemistry	Paper Engineering
Electrical Engineering	Physics
Industrial Management	Plastics Technology
Mathematics	Textile Chemistry
Mechanical Engineering	Textile Engineering
Meterology	Textile Technology

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute.

Number following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6) 4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6) 6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

THE ELECTIVE SYSTEM

In all curricula an opportunity is afforded the student to elect subjects in addition to those required for graduation. These fall into two categories: Technical Electives and General Electives.

Technical Electives give the student a chance to broaden his professional knowledge by taking courses allied to his field of concentration or to further his knowledge of a particular phase by additional work therein.

General Electives are to be selected from the following list of subjects. At least two electives must be chosen in the social sciences (SS) and two in languages and literature (LL). The total number of such electives must meet the requirements of the particular curriculum being pursued.

Subjects required in the Air Force ROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects required in the junior and senior years in the ROTC program may be substituted for General Electives in all curricula unless otherwise specified.

EC	201	Economics I		(3-0) 3
EC	202	Economics II		(3-0) 3
EC	301	Economic Development of The United States		(3-0) 3
EC	302	Labor Economics		(3-0) 3
EC	303	Microeconomic Theory		(3-0) 3
EC	304	Macroeconomic Theory		(3-0) 3
LL	213	Introduction to English Literature		(3-0) 3
LL	214	Introduction to American Literature		(3-0) 3
LL	233	Comparative Literature		(3-0) 3
LL	234	Shakespeare		(3-0) 3
*LL	261-262	Elementary Technical German	(3-0)	(3-0) 6
LL	263-264	Elementary French	(3-0)	(3-0) 6
*LL	265-266	Elementary Technical Russian	(3-0)	(3-0) 6
LL	267-268	Elementary Spanish	(3-0)	(3-0) 6
LL	333	Problems of Philosophy		(3-0) 3
LL	363-364	Intermediate French	(3-0)	(3-0) 6
*LL	365-366	Intermediate Literary and Conversational Russian	(3-0)	(3-0) 6
LL	367-368	Intermediate Literary and Conversational German	(3-0)	(3-0) 6

LL	369-370	Intermediate Spanish	(3-0)	(3-0) 6
LL	436	English Romanticism		(3-0) 3
LL	467	Advanced Seminar in Literary German		(3-0) 3
LL	471	The Modern American Novel		(3-0) 3
LL	472	The Modern British Novel		(3-0) 3
LL	473	World Drama		(3-0) 3
LL	474	Modern Drama		(3-0) 3
LL	476	The Nineteenth Century British Novel		(3-0) 3
LL	482	The American Short Story		(3-0) 3
SS	223	The United States: 1865-1912		(3-0) 3
SS	224	The United States: 1912 to The Present		(3-0) 3
SS	225	Europe: 1789-1914		(3-0) 3
SS	227	Europe: 1914-1939		(3-0) 3
SS	228	Europe: 1939 to The Present		(3-0) 3
SS	301	Government of The United States		(3-0) 3
SS	303	Psychology		(3-0) 3
SS	305	Sociology		(3-0) 3
SS	372	American Civilization to 1865		(3-0) 3
SS	403	Psychological Warfare in Foreign Policy		(3-0) 3
SS	459	World Politics: The Central Problem of War		(3-0) 3
SS	460	Foreign Aid and Foreign Policy		(3-0) 3
SS	464	World Politics: Problems of International Organization		(3-0) 3
SS	471	The United States in World Politics		(3-0) 3
SS	472	Defense Policy		(3-0) 3
SS	477	Twentieth Century Russia		(3-0) 3
SS	479	The Far East Since 1842		(3-0) 3
SS	481	The Greeks and Western Civilization		(3-0) 3
SS	483	Political and Social Thought: Ancient to Early Modern Times		(3-0) 3
SS	484	Political and Social Thought: Early Modern Times to The Present		(3-0) 3
SS	485	The Romans and Western Civilization		(3-0) 3
SS	487	American Political Thought to 1865		(3-0) 3
SS	488	American Political Thought Since 1865		(3-0) 3
SS	489	Nationalism and Imperialism Since 1800		(3-0) 3
SS	492	Twentieth Century Germany		(3-0) 3
SS	494	Totalitarian Systems of the Twentieth Century		(3-0) 3

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* These subjects are not accepted for credit, except as an overload, in Chemistry, Chemical Engineering, Electrical Engineering, Mechanical Engineering, Nuclear Engineering, Paper Engineering, and Textile Engineering.

THE AIR FORCE ROTC PROGRAM

The program is designed to qualify for commissions those men who desire to serve in the United States Air Force, and to provide an education that will develop skills and attitudes vital to professional Air Force officers.

The Air Force ROTC Program is divided into two phases: the General Military Course (GMC) the first two college years and the Professional Officer Course (POC) the last two years.

A student may elect to enroll in the Two-Year AFROTC Program or the Four-Year AFROTC Program. To qualify for enrollment in the Two-Year Program, a student must have two academic years remaining at either the graduate or undergraduate level or a combination of the two. He must also meet certain physical standards and pass an Officer Qualification Examination. Further, he must successfully complete a six weeks Field Training Course before he can be accepted into the Professional Officer Course. Students in the Two-Year Program are not eligible to compete for the AFROTC Financial Assistance Program. Transfer students may elect the Professional Officer Course by satisfying the above requirements. A student electing the Four-Year Program will take the General Military Course during his freshman and sophomore years and the Professional Officer Course during his junior and senior years. He will attend four weeks of Field Training during the summer between his junior and senior years . As a member of the Four-Year Program he is eligible to compete for the equivalent of a scholarship through the Financial Assistance Program. For acceptance into the POC the Four-Year Program student must pass a physical examination and an Officer Qualification Test.

Uniforms and all equipment and textbooks required for AFROTC work are supplied by the United States Air Force. Students in the Professional Officer Course receive a $40.00 a month retainer fee. Additional financial assistance is available to a limited number of cadets in the four-year program on a competitive basis.

Students who successfully complete the Professional Officer Course are commissioned as second lieutenants in the United States Air Force Reserve. Those who qualify may receive further training after commissioning in scientific skills, pilot or navigator training, or administration. Outstanding seniors who are designated Distinguished AFROTC Cadets may apply for regular commissions and postgraduate education assignments.

GENERAL MILITARY COURSE

FRESHMAN YEAR

First Semester

AS 101	World Military Systems I	(1-1) 1

Second Semester

AS 102	World Military Systems II	(1-1) 1

SOPHOMORE YEAR

First Semester

AS 201	World Military Systems III	(1-1) 1

Second Semester

AS 202	World Military Systems IV	(1-1) 1

PROFESSIONAL OFFICER COURSE

JUNIOR YEAR

First Semester

AS 301	Growth and Development of Aerospace Power I	(3-1) 3

Second Semester

AS 302	Growth and Development of Aerospace Power II	(3-1) 3

SENIOR YEAR

First Semester

AS 401	The Professional Officer I	(3-1) 3

Second Semester

AS 402	The Professional Officer II	(3-1) 3

Subjects required in the AFROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects required in the AFROTC program in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

CORPS TRAINING

Corps Training is conducted one hour each week. This is an assembly of the entire cadet corps under the direction of the cadet officers and staff wherein the General Military Course

cadets learn the rudiments of marching and drill and the Professional Officer Course cadets develop their capability to lead, maneuver and command marching troops.

FIELD TRAINING

Field Training is held at several combat operational bases each summer where cadets have the opportunity to observe, fly and live with career personnel. Transportation from the legal residence of the cadet to the Field Training base and return, food, lodging and medical and dental care are provided by the Air Force. In addition, the cadet receives approximately $138 for the four week Field Training and $131 for the six week Field Training.

Field Trips

Periodically, the Department of Aerospace Studies conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

Flight Instruction

The Flight Instruction Program (FIP), designed for seniors in the Professional Officer Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio, and weather. The flying phase consists of 36½ hours of flight instruction at government expense.

Cadet Decorations and Awards

A number of medals are awarded to selected cadets and cadet officers at a special parade and review held each spring. These include the Thomas F. Costello Trophy, the Alumni Medal, the Convair Cadet Award, the "Chicago Tribune" Awards, the Armed Forces Communications and Electronics Association Award, the Sons of the American Revolution ROTC Award, the Trustees' Medal, the Reserve Officer Association Medal, the Air Force Association Medal, the "Air Force Times" Award, and the Vandenberg Cup.

In addition, the Department of Air Science confers several medals and awards for outstanding performance in various fields, among them the Distinguished Military Cadet Awards.

Distinguished AFROTC Graduate Awards are given to outstanding graduates, based on academic and military achievements. A recipient of this award may apply for a regular commission as a Second Lieutenant in the United States Air Force.

THE FRESHMAN PROGRAM

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Business Administration,* Industrial Management,† or Mechanical Engineering** take the following subjects:

First Semester

CH	001	Chemical Principles	(4-0) 3
CH	003	Chemical Principles Laboratory	(0-2) 1
LL	111	English I	(3-0) 3
MA	107	Calculus and Analytic Geometry	(4-0) 4
ME	101	Engineering Graphics	(1-2) 1
PH	103	Physics	(4-1) 4
		Total hours	(16-5) 16

Second Semester

CH	002	Chemical Principles	(4-0) 3
CH	004	Chemical Principles Laboratory	(0-2) 1
LL	112	English II	(3-0) 3
MA	108	Calculus and Analytic Geometry	(4-0) 4
ME	102	Engineering Graphics	(1-2) 1
PH	104	Physics	(4-2) 4
		Total hours	(16-6) 16

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. AFROTC students are excused from one hour per week. No academic credit is given for the physical education program.

* The freshman program in Business Administration is given on the next page.

† Majors in Industrial Management substitute EC201, Economics I (3-0) 3, for PH 103, and EC 202, Economics II (3-0) 3, for PH 104.

** Majors in Mechanical Engineering substitute PH 105, Introduction to Physics (4-1) 4 for PH 103, and PH 106, Introduction to Physics (4-2) 4 for PH 104.

BUSINESS ADMINISTRATION

The specific objective of the curriculum in Business Administration is to provide an undergraduate liberal and professional education for young men and women who have the qualifications and the ambition to be administrators and executives.

The curriculum offers an integration of the traditional liberal arts subjects and those professional subjects which provide the basic foundations of management science. The emphasis in this area is not technical but administrative. A core of business subjects—accounting, economics, finance, business law, statistics, marketing, production—is required of the student. In the junior year the student is permitted limited concentration in one of the following fields: accounting,* economics, finance, marketing, or production. This specialization affords the student a deeper penetration of the area he expects to work in after graduation. It is limited, however, in order not to detract from the broad professional goals of the program as a whole.

* Accounting specialization starts in the sophomore year.

FRESHMAN YEAR

First Semester

BA	141	Accounting I	(2-2) 3
EC	201	Economics I	(3-0) 3
LL	111	English I	(3-0) 3
MA	101	Mathematical Analysis I	(3-0) 3
		Science Elective†	(3 or 4)
		Total credit hours	15 or 16

Second Semester

BA	142	Accounting II	(2-2) 3
EC	202	Economics II	(3-0) 3
LL	112	English II	(3-0) 3
MA	102	Mathematical Analysis II	(3-0) 3
		Science Elective†	3 or 4
		Total credit hours	15 or 16

† Physics, chemistry, biology. (Two semesters of one science must be taken.)

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. AFROTC students are excused from one hour per week. No academic credit is given for the physical education program.

SOPHOMORE YEAR

First Semester

EC	211	Economic Statistics I	(3-0) 3
EC	301	Economic Development of the U. S.	(3-0) 3
MA	201	Mathematic Analysis III	(3-0) 3
		Behavioral Science Elective*	(3-0) 3
		English Elective	(3-0) 3
		Total hours	(15-0) 15

Second Semester

BA	344	Cost Accounting or BA 346 Managerial Accounting	(2-2) 3
EC	212	Economic Statistics II	(3-0) 3
MA	202	Mathematical Analysis IV	(3-0) 3
		Behavioral Science Elective*	(3-0) 3
		English Elective	(3-0) 3
		Total hours	(14-2) 15

* Sociology, psychology, or accounting. (Accounting must be taken by students majoring in this subject.)

JUNIOR YEAR

First Semester

BA	321	Marketing Principles	(3-0) 3
BA	331	Business Finance	(3-0) 3
BA	362	Business Law	(3-0) 3
BA	371	Production Management I	(3-0) 3
		Humanities Elective†	(3-0) 3
		Business Elective* (or Aerospace Studies)	3
		Total credit hours	18

Second Semester

BA	322	Marketing Problems	(3-0) 3
BA	332	Money and Banking	(3-0) 3
BA	372	Production Management II	(3-0) 3
EC	302	Labor Economics	(3-0) 3
		Humanities Elective†	(3-0) 3
		Business Elective* (or Aerospace Studies)	3
		Total credit hours	18

† English, history, social science, or a foreign language. (A two-year commitment is required for language credit.)

* See list of electives at end of curriculum.

SENIOR YEAR

First Semester

BA	402	International Business Operations	(3-0) 3
BA	451	Personnel Management	(3-0) 3
BA	481	Insurance	(3-0) 3
EC	402	Government and Business	(3-0) 3
		Business Elective *	
		Humanities Elective or Aerospace Studies †	3
		Total credit hours	18

Second Semester

BA	452	Industrial Relations	(3-0) 3
BA	492	Transportation	(3-0) 3
EC	412	Managerial Economics	(3-0) 3
		Two Business Electives *	(6-0) 6
		Humanities Elective or Aerospace Studies †	3
		Total credit hours	18

* Business Electives: accounting, economics, finance, and marketing. (A student must have 12 hours in one area in order to receive credit for concentration in that area.)

† Humanities Electives: English, history, social sciences, and foreign languages. (A two-year commitment is required for language credit.)

CHEMICAL ENGINEERING

This curriculum is designed to provide the student with a firm understanding of scientific principles as well as practical engineering competence. Graduates are qualified to enter industry or proceed to graduate studies.

A strong background is provided in the sciences in the first two years, with emphasis being placed upon chemical engineering and other engineering subjects in the junior and senior years. Oral and written reports are required in most courses to train the student in clear thinking and sound presentation of engineering facts. The courses of industrial chemistry, unit operations laboratory, and economic balance and plant design in the senior year prepare the student to enter the chemical industry, the petroleum industry, the plastics industry, or graduate work in chemical engineering.

The stability of the chemical industry, coupled with its strong and continued growth, provides the graduate with unrivalled opportunities. The broad training of the chemical engineer permits him to enter research and development, production, sales, and market development areas of business; it also gives him the tools to develop a career which is both challenging and satisfying.

To be admitted to the Chemical Engineering Curriculum a freshman must have a minimum of 2.0 rating at the end of his freshman year, or special permission of the Chairman of the Department.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3) 4
CH	209	Analytical Techniques	(1-3) 2
CHE	203	Introduction to Chemical Engineering	(3-0) 3
LL	209	Technical Report Writing	(2-0) 2
MA	205	Calculus and Analytic Geometry	(4-0) 4
PH	205	Physics	(4-2) 4
		Total hours	(17-8) 19

Second Semester

CH	202	Organic Chemistry	(3-3) 4
CHE	204	Industrial Stoichiometry	(3-0) 3
EE	355	Electrical Controls and Power Circuits	(1½-1½) 3
LL	214	Introduction to American Literature	(3-0) 3
MA	206	Differential Equations	(3-0) 3
		Total hours	(13½-4½) 16

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3) 4
CHE	303	Chemical Engineering I	(3-0) 3
CHE	311	Chemical Engineering Thermodynamics	(3-0) 3
CHE	313	Industrial Instrumentation *	(3-0) 3
ME	215	Analytic Mechanics I	(3-0) 3
		General Elective	3
		Total credit hours	19

* ROTC Students take AS 301

Second Semester

CH	332	Physical Chemistry	(3-3) 4
CHE	304	Chemical Engineering II	(3-0) 3
ME	216	Analytic Mechanics II	(3-0) 3
		Technical Elective *	3
		General Elective	3
		Total credit hours	16

* ROTC Students take AS 302

SENIOR YEAR

First Semester

CHE	405	Chemical Engineering III	(3-0) 3
CHE	411	Unit Operations Laboratory	(0-6) 2
EC	201	Economics I	(3-0) 3
		Technical Elective *	3
		Technical Elective **	3
		General Elective	3
		Total credit hours	17

*Recommended Technical Elective

CHE	407	Engineering Analysis of Chemical Processes	(3-0) 3

* ROTC Students take AS 401

Second Semester

CHE	410	Process Analysis and Design	(3-0) 3
CHE	412	Unit Operations Laboratory	(0-6) 2
EC	202	Economics II	(3-0) 3
		Technical Elective *	3
		Technical Elective ** or General Elective	3
		General Elective	3
		Total credit hours	17

*Recommended Technical Elective

CHE	408	Engineering Materials	(3-0) 3

* ROTC Students take AS 402

CHEMISTRY

The curriculum in Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry after graduation, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the Committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

Admission to the sophomore year in the curriculum is contingent upon the student's receiving a minimum average grade of C— in the two semesters of Chemical Principles, (CH 001-002) in his freshman year.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3) 4
CH	207	Electrolytic Solutions	(2-3) 3
CH	209	Analytical Techniques	(1-3) 2
MA	205	Calculus and Analytic Geometry	((4-0) 4
PH	205	Physics	(4-2) 4
		Total credit hours	(14-11) 17

Second Semester

CH	202	Organic Chemistry	(3-3) 4
CH	208	Inorganic Chemistry	(3-0) 3
CH	210	Analytical Chemistry	(3-6) 5
MA	206	Differential Equations	
	or		(3-0) 3
MA	384	Statistical Methods	
PH	206	Physics	(4-2) 4
		Total credit hours	(16-11) 19

JUNIOR YEAR

First Semester

CH	321	Organic Chemistry Laboratory II	(1-6) 3
CH	331	Physical Chemistry	(3-3) 4
EC	201	Economics I	(3-0) 3
LL	261	Elementary Technical German	(3-0) 3
		General Elective	(3-0) 3
		Technical Elective or AS 301	3
		Total credit hours	19

Second Semester

CH	332	Physical Chemistry	(3-3) 4
CH	342	Organic Qualitative Analysis	(1-6) 3
EC	202	Economics II	(3-0) 3
LL	262	Elementary Technical German	(3-0) 3
		General Elective	(3-0) 3
		Technical Elective or AS 302	3
		Total credit hours	19

SENIOR YEAR

First Semester

CH	411 *	Advanced Analytical Chemistry	(2-4) 3
CH	443 *	Advanced Inorganic Chemistry	(3-0) 3
		Two General Electives	(6-0) 6
		Technical Elective	3
		Technical Elective or AS 401	3
		Total credit hours	18

Second Semester

CH	444 *	Advanced Inorganic Chemistry	(3-0) 3
		Two General Electives	(6-0) 6
		Technical Elective	3
		Technical Elective or AS 402	3
		Total credit hours	15

Seniors are strongly advised to take CH 423-424 * (Advanced Organic Chemistry) or CH 431-432 * (Advanced Physical Chemistry) as one of the technical electives. Other technical electives include CH 403-404, CH 407-408, and CH 481.*

ELECTRICAL ENGINEERING

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering with emphasis in electronics.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classroom.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences, with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of nontechnical knowledge in determining the student's ultimate level of responsibility in professional life.

The criteria used for determining which students from the freshman class seeking admission to major in Electrical Engineering are acceptable as sophomores are as follows:

1. A minimum rating of 2.00 for the second semester of the freshman year.
2. No unremoved failures in freshman subjects.
3. A grade of C (not C—) or higher in MA 108 and PH 104.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0) 3
EE	201	Introductory Circuit Theory	(4-0) 4
EE	205	Basic Electrical Engineering Laboratory*	(0-3/2) 0*
MA	205	Calculus and Analytic Geometry	(4-0) 4
PH	205	Physics	(4-1) 4
		Total hours	(15-2½) 15

Second Semester

EC	202	Economics II	(3-0) 3
EE	202	Introductory Circuit Theory	(4-0) 4
EE	206	Basic Electrical Engineering Laboratory*	(0-3/2) 1
MA	206	Differential Equations	(3-0) 3
ME	212	Mechanics and Properties of Matter	(4-0) 4
		Total hours	(14-1½) 15

*The notation 3/2 means that the laboratory meets for 3 hours every other week, and consequently no credit is given for laboratory until the completion of the second semester.

JUNIOR YEAR

First Semester

EE	301	Electronic Devices/Models	(4-0) 4
EE	309	Electronic Devices Laboratory	(0-3) 1
EE	315	Network Analysis	(4-0) 4
MA	311	Engineering Mathematics	(3-0) 3
		General Elective (from approved list)	(3-0) 3
		Total hours	(14-3) 15

Second Semester

EE	302	Electronic Devices/Models	(4-0) 4
EE	306	Electromagnetic Theory	(4-0) 4
EE	310	Electronic Devices Laboratory	(0-3) 1
		Technical Elective (from approved list) or AS 302	3
		General Elective (from approved list)	(3-0) 3
		Total credit hours	15

SENIOR YEAR

First Semester

General Elective (from approved list)	3 credits
EE Technical Electives	8 credits
AS 401 or Elective	3 credits
Minimum credit hours per semester	14

Second Semester

General Elective (from approved list)	3 credits
EE Technical Electives	8 credits
AS 402 or Elective	3 credits
Minimum credit hours per semester	14

INDUSTRIAL MANAGEMENT

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide the student with a foundation in science and engineering, in the humanities, and in the social sciences. In addition, the various aspects of management—business organization, production, distribution, accounting, and finance—are studied. The student extends his knowledge of mathematics to include statistics. He is also introduced to the newer research methods, including operations research, linear programming, and game theory. A graduate of this program can expect to find employment as a specialist in accounting, procurement, administration, technical sales, or personnel management.

SOPHOMORE YEAR

First Semester

BA	141	Accounting I	(2-2) 3
BA	321	Marketing Principles	(3-0) 3
EC	211	Economic Statistics I	(3-0) 3
ME	263	Metals Processes	(1-2) 1
PH	103	Physics	(4-1) 4
		English Elective	(3-0) 3
		Total hours	(16-5) 17

Second Semester

BA	142	Accounting II	(2-2) 3
BA	324	Industrial Marketing	(3-0) 3
EC	212	Economic Statistics II	(3-0) 3
PH	104	Physics	(4-2) 4
		English Elective	(3-0) 3
		Total hours	(15-4) 16

JUNIOR YEAR

First Semester

BA	331	Business Finance	(3-0) 3
BA	371	Production Management I	(3-0) 3
IM	351	Motion and Time Study	(0-2) 1
ME	315	Applied Mechanics	(3-0) 3
ME	377	Elements of Materials Science	(2-0) 2
SS	303	Psychology	(3-0) 3
		Concentration Elective *	3 or 4
		Total credit hours	18 or 19

* Concentration areas and subject sequences are:

(A)	Air Science	AS 301, 302, 401, 402.
(B)	Economics	EC 303, 304, 407, 408.
(C)	Accounting	BA 241, 242, 341, 342.
(D)	Finance	BA 241, 242, 431, 334.
(E)	Marketing	BA 325, 326, 423, 426.
(F)	Math and Physics	MA 205, 206, PH 205, 206

The concentration sequence selected by the student must be followed through the senior year unless a waiver is granted by the Department Head.

Second Semester

BA	332	Money and Banking	(3-0) 3
BA	344	Cost Accounting (for Accounting students)	
	or		
BA	346	Managerial Accounting	(2-2) 3
BA	372	Production Management II	(3-0) 3
EC	302	Labor Economics	(3-0) 3
ME	372	Strength of Materials	(3-0) 3
		Concentration Elective	(3-0) 3
		Total hours	(17-2) 18

SENIOR YEAR

First Semester

BA	451	Personnel Management	(3-0) 3
EC	301	Economic Development of the U. S.	(3-0) 3
EE	351	Industrial Electronics	(3-0) 3
IM	483	Statistical Quality Control	(3-0) 3
		Management Elective *	(3-0) 3
		Concentration Elective	3 or 4
		Total credit hours	18 or 19

Second Semester

BA	362	Business Law	(3-0) 3
EC	402	Government and Business	(3-0) 3
EC	412	Managerial Economics	(3-0) 3
ME	344	Heat and Power	(3-0) 3
		Management Elective *	(3-0) 3
		Concentration Elective	3 or 4
		Total credit hours	18 or 19

* BA 326, 334, 341, 342, 402, 421, 423, 426, 431, 441, 444, 445, 452, 481, 492, 500.
EC 303, 304, 403, 404, 407, 408.
IM 371, 494, 500.
SS 305.

MATHEMATICS

The objectives of the Mathematics program, which begins with the Class of 1969, are twofold: (1) to provide the student with the opportunity to become acquainted with the major areas of modern mathematics—algebra, analysis, geometry and applied mathematics, including computing science and numerical analysis, and (2) to enable him to achieve a certain mastery in depth of one or more of these areas.

The approaches to these objectives are also twofold, viz., by way of course work and supervised project activity. In order to achieve breadth, each of the major areas mentioned above is represented by at least one required three-hour subject. A deeper study of one or more areas is provided by the student's elective program, subject to the approval of his departmental advisor.

The purpose of the project work is to enable the student to "read, write, and speak" mathematics, via the reading of simple journal articles, the preparation of short papers, and oral presentations. This aspect of the program is regarded as at least as important as the formal course work. Participation in a working seminar is required of all mathematics majors, during both junior and senior years.

As designed, the curriculum exceeds the minimum recommendations of the Committee on Undergraduate Programs in Mathematics of the Mathematical Association of America for college mathematics programs. It provides a strong basis both for subsequent graduate study and for employment in the several fields as involved in teaching and industry.

A student may be admitted to the Mathematics major program provided he has attained a cumulative rating of at least 2.0 at the end of his freshman year, and his mathematics grades are better than C—.

SOPHOMORE YEAR

First Semester

LL	261	Elementary Technical German	
or			
LL	263	Elementary French	(3-0) 3
or			
LL	265	Elementary Technical Russian	
MA	205	Calculus and Analytic Geometry	(4-0) 4
MA	221	Linear Algebra	(3-0) 3
PH	205	Physics	(4-2) 4
		General Elective	(3-0) 3
		Total hours	(17-2) 17

Second Semester

LL	262	Elementary Technical German	
or			
LL	264	Elementary French	(3-0) 3
or			
LL	266	Elementary Technical Russian	
MA	206	Differential Equations	(3-0) 3
MA	222	Linear Algebra	(3-0) 3
MA	355	Digital Computer Programming	(2-2) 2
PH	206	Physics	(4-2) 4
		General Elective	(3-0) 3
		Total hours	(18-4) 18

JUNIOR YEAR

First Semester

MA	307	Advanced Calculus	(3-0) 3
MA	321	Modern Algebra I	(3-0) 3
MA	395	Seminar	(1-0) 1
		Applied Mathematics Elective*	(3-0) 3
		Technical or General Elective	(3-0) 3
		General Elective	(3-0) 3
		Total hours	(16-0) 16

* To be selected from an approved departmental list.

Second Semester

MA	308	Advanced Calculus	(3-0) 3
MA	334	Projective Geometry	(3-0) 3
MA	396	Seminar	(1-0) 1
		Mathematics Elective	(3-0) 3
		Technical or General Elective	(3-0) 3
		General Elective	(3-0) 3
		Total hours	(16-0) 16

SENIOR YEAR

First Semester

MA 411	Complex Variables I		(3-0) 3
MA 431	Point Set Topology		(3-0) 3
MA 495	Seminar		(1-0) 1
	Mathematics Elective		(3-0) 3
	Technical or General Elective		(3-0) 3
	General Elective		(3-0) 3
		Total hours	(16-0) 16

Second Semester

MA 412	Complex Variables II		(3-0) 3
MA 496	Seminar		(1-0) 1
	Mathematics Elective		(3-0) 3
	Technical or General Elective		(3-0) 3
	General Elective		(3-0) 3
		Total hours	(13-0) 13

MECHANICAL ENGINEERING

This course trains the student in the application of the facts and methods of mathematics and science to the design and use of machinery and processes. Principles of design and analysis are stressed in all subjects, and the systems point of view is emphasized.

The student is thoroughly instructed in basic mathematics, physics, and chemistry. There is a unified sequence in applied mechanics which focuses on a course in design given in the senior year. The properties of engineering materials and the principles of thermodynamics, fluid mechanics, and heat transfer are taught, together with a series of subjects in electrical engineering.

In the laboratory the student becomes familiar with design techniques associated with typical energy conversion devices, controls, and instrumentation.

This curriculum is accredited by the Engineers' Council for Professional Development.

Requirements for admission to the sophomore year are a 2.00 cumulative average, no failures or incomplete courses, and a C average or better in freshman mathematics and physics.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0) 3
EE	205	Basic Electrical Engineering Laboratory	(0-1 ½) 0
EE	211	Fundamentals of Electricity	(3-0) 3
MA	205	Calculus and Analytic Geometry	(4-0) 4
ME	201	Mechanical Engineering Laboratory I	(2-2) 2
ME	203	Introduction to Mechanical Engineering	(1-0) 1
ME	211	Engineering Mechanics I	(3-0) 3
ME	263	Metals Processes	(1-2) 1
		Total hours	(17-5 ½) 17

Second Semester

EC	202	Economics II	(3-0) 3
EE	206	Basic Electrical Engineering Laboratory	(0-1 ½) 1
EE	212	Introductory Electronics	(3-0) 3
MA	206	Differential Equations	(3-0) 3
MA	459	Digital Computer Programming and Numerical Analysis	(2-3) 3
ME	214	Engineering Mechanics II	(3-0) 3
		General Elective	(3-0) 3
		Total hours	(17-4 ½) 19

JUNIOR YEAR

First Semester

MA	311	Engineering Mathematics	(3-0) 3
MA	460	Digital Computer Programming and Numerical Analysis	(2-3) 3
ME	311	Mechanics of Materials I	(3-0) 3
ME	341	Thermodynamics I	(3-0) 3
ME	375	Materials Science	(3-0) 3
		General Elective	(3-0) 3
		Total credit hours	(17-3) 18

Second Semester

ME	314	Mechanical Engineering Laboratory II	(0-3) 1
ME	318	Engine Dynamics	(3-0) 3
ME	342	Thermodynamics II	(3-0) 3
ME	382	Fluid Mechanics I	(3-0) 3
ME	394	Automatic Control Systems I	(3-0) 3
		General Elective	(3-0) 3
		General Elective	(3-0) 3
		Total credit hours	(18-3) 19

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory III	(0-3) 1
ME	421	Machine Design	(2-3) 3
ME	443	Heat Transfer	(3-0) 3
ME	482	Fluid Mechanics II	(3-0) 3
ME	495	Automatic Control Systems II	(3-2) 4
		Technical Elective or AS 401	3
		Total credit hours	17

Technical Electives

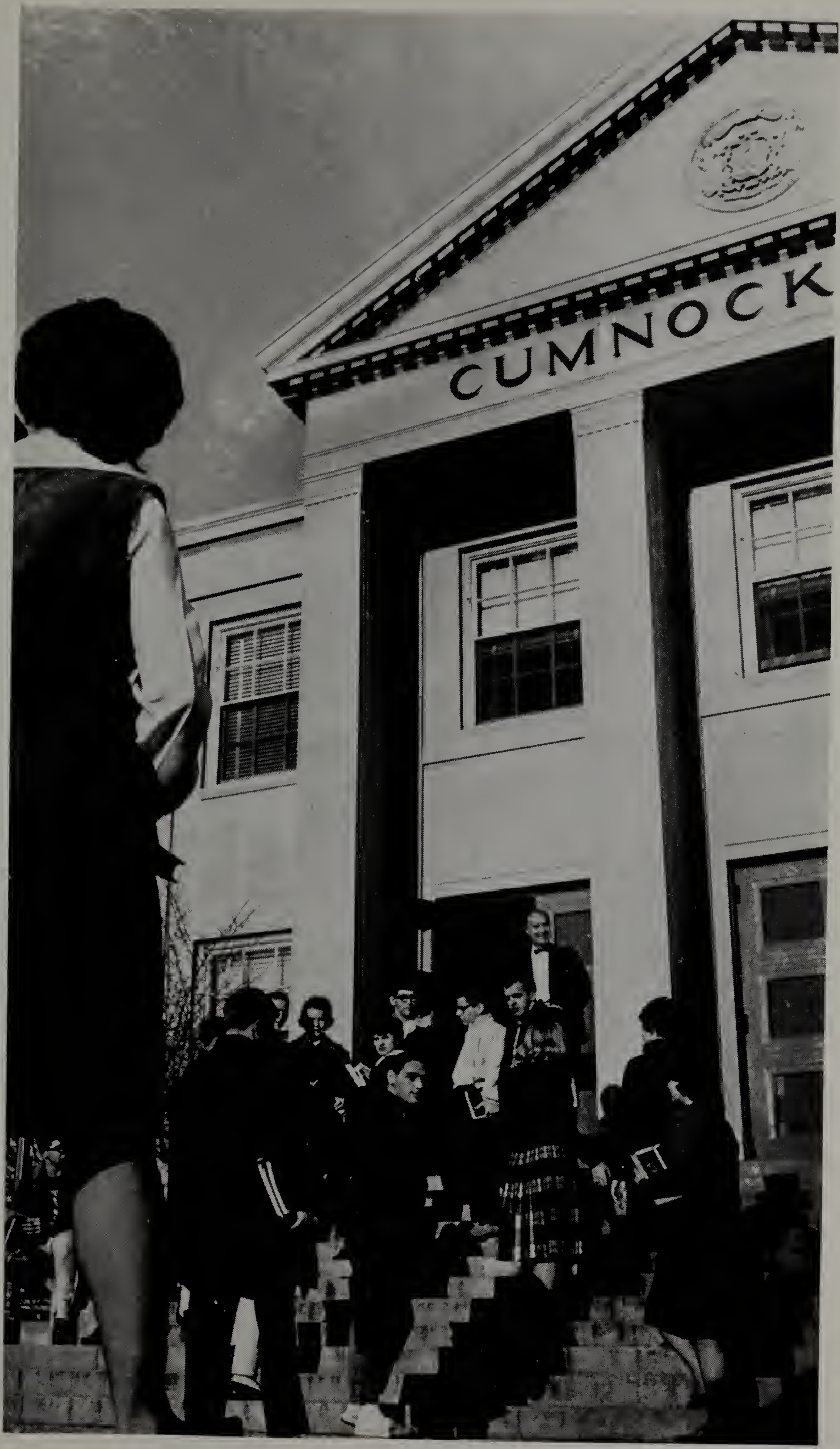
ME	455	Information Processing Systems	(2-2) 3
ME	471	Experimental Stress Analysis	(2-2) 3
ME	491	Measurement Engineering	(3-0) 3
ME	541	Statistical Thermodynamics	(3-0) 3
ME	581	Orbital and Ballistic Mechanics	(3-0) 3

Second Semester

ME	416	Senior Project	(0-3) 1
ME	422	Mechanical Engineering Design	(2-3) 3
ME	442	Selected Problems in Thermal Engineering	(2-0) 2
ME	474	Mechanics of Materials II	(3-0) 3
		General Elective	(3-0) 3
		Technical Elective	3
		Technical Elective or AS 402	3
		Total credit hours	18

Technical Electives

EC	414	Engineering Economy	(3-0) 3
ME	456	Information Processing Systems	(2-2) 3
ME	472	Experimental Stress Analysis	(2-2) 3
ME	476	Physical Metallurgy	(3-0) 3
ME	528	Kinematic Mechanism Synthesis	(3-0) 3
ME	542	Direct Energy Conversion	(3-0) 3
ME	556	Advanced Computer Problems	(3-0) 3
ME	576	Nondestructive Evaluation Techniques for Materials and Processes	(3-0) 3
ME	582	Aero- and Astrodynamics	(3-0) 3


CUMNOCK

METEOROLOGY

A four-year program leading to the Bachelor of Science degree in Meteorology was started in the fall semester 1965-1966. The program is in the final stages of organization and is being designed to train students in the fundamentals of atmospheric sciences and prepare them for the many industries and government agencies requiring meteorologists. It is also suitable background for graduate work in the field.

Mathematics, the physical sciences, and some elements of electrical engineering are so essential that during the first two years the program is built on these subjects. The freshman year is the one common to the programs in science and engineering.

In the field of meteorology will be included such subjects as Survey of the Atmosphere, Dynamic Meteorology, Meteorological Instrumentation, Synoptic Meteorology, Physical Meteorology, Climatology. Much of the work involves laboratory exercises based on the basic theories and probability studies.

Enrollment beyond the freshman year will depend upon the student's receiving a minimum rating of 2.00 for the second semester of the freshman year and grades of at least C in both physics and mathematics.

NUCLEAR ENGINEERING

The Nuclear Engineering course was the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.00, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

NUCLEAR ENGINEERING

SOPHOMORE YEAR

First Semester

EE	205	Basic Electrical Engineering Laboratory	(0-3/2) 0
EE	211	Fundamentals of Electricity	(3-0) 3
MA	205	Calculus and Analytic Geometry	(4-0) 4
NU	201	Introduction to Nuclear Engineering	(3-0) 3
PH	205	Physics	(4-2) 4
		General Elective	(3-0) 3
		Total hours	(17-3½) 17

Second Semester

EE	206	Basic Electrical Engineering Laboratory	(0-3/2) 1
EE	212	Introductory Electronics	(3-0) 3
MA	206	Differential Equations	(3-0) 3
NU	202	Introduction to Nuclear Engineering	(3-0) 3
PH	208	Modern Physics	(3-2) 4
		General Elective	(3-0) 3
		Total hours	(15-3½) 17

JUNIOR YEAR

First Semester

MA	301	Functions and Their Applications	(3-0) 3
ME	341	Thermodynamics	(3-0) 3
NU	301	Radiological Health	(3-0) 3
NU	305	Nuclear Instrumentation	(2-4) 3
PH	363	Introductory Nuclear Physics	(3-0) 3
		General Elective	(3-0) 3
		Total hours	(17-4) 18

Second Semester

MA	302	Functions and Their Applications	(3-0) 3
ME	342	Thermodynamics	(3-0) 3
ME	382	Fluid Mechanics	(3-0) 3
NU	302	Radiological Health	(3-0) 3
NU	306	Nuclear Instrumentation	(2-4) 3
		General Elective	(3-0) 3
		Total hours	(17-4) 18

SENIOR YEAR

First Semester

MA	459	Digital Computer Programming and Numerical Analysis	(2-3) 3
ME	443	Heat Transfer	(3-0) 3
NU	405	Nuclear Reactor Engineering	(3-0) 3
NU	410	Reactor Safety and Site Analysis	(3-0) 3
NU	493	Nuclear Laboratory	(0-6) 2
		General Elective	(3-0) 3
		Total hours	(14-9) 17

Second Semester

CH	484	Elements of Radiochemistry	(3-3) 4
MA	460	Digital Computer Programming and Numerical Analysis	(2-3) 3
NU	406	Nuclear Reactor Engineering	(3-0) 3
NU	494	Nuclear Laboratory	(0-6) 2
PH	366	Intermediate Nuclear Physics	(3-0) 3
		General Elective	(3-0) 3
		Total hours	(14-12) 18

NUCLEAR SCIENCE

The course in Nuclear Science was the first to be offered by a publicly supported institution in New England. The curriculum emphasizes those fundamental subjects in physics and mathematics necessary for the basic education of a physicist who desires to work in this field, and thus prepares the graduate for advanced studies as well as for responsible positions in industry.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.00 and no unremoved failures; in freshman physics and mathematics only, a cumulative average of 2.50 and no unremoved grades below C—. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

LL	261	Elementary Technical German	
or			
LL	263	Elementary French	
or			
LL	265	Elementary Technical Russian	(3-0) 3
MA	205	Calculus and Analytic Geometry	(4-0) 4
PH	205	Physics	(4-2) 4
PH	209	Problems in Physics	(1-0) 1
PH	257	Electric Circuits	(2-0) 2
PH	293	Laboratory Practice	(1-2) 1
		Total hours	(18-4) 18

Second Semester

EE	212	Introductory Electronics	(3-0) 3
LL	262	Elementary Technical German	
or			
LL	264	Elementary French	
or			
LL	266	Elementary Technical Russian	(3-0) 3
MA	206	Differential Equations	(3-0) 3
PH	242	Modern Physics	(3-2) 4
PH	258	Electrical Measurements	(1-3) 2
		General Elective	(3-0) 3
		Total hours	(16-5) 18

JUNIOR YEAR

First Semester

MA	301	Functions and Their Applications	(3-0) 3
PH	311	Intermediate Mechanics	(3-0) 3
PH	345	Atomic and Nuclear Physics	(3-0) 3
PH	353	Electromagnetic Theory	(3-0) 3
PH	393	Experimental Physics	(1-3) 1
		General Elective	(3-0) 3
		Total hours	(16-3) 16

Second Semester

MA	302	Functions and Their Applications	(3-0) 3
PH	312	Intermediate Mechanics	(3-0) 3
PH	346	Atomic and Nuclear Physics	(3-0) 3
PH	354	Electromagnetic Theory	(3-0) 3
PH	394	Experimental Physics	(1-3) 1
		General Elective	(3-0) 3
		Total hours	(16-3) 16

SENIOR YEAR

First Semester

MA	433	Matrix Algebra	(3-0) 3
NU	301	Radiological Health	(3-0) 3
NU	305	Nuclear Instrumentation	(2-4) 3
NU	493	Nuclear Laboratory	(0-6) 2
		General Elective	(3-0) 3
		Technical Elective	3
		Total credit hours	17

Technical Electives

MA	573	Functions of a Complex Variable	(3-0) 3
NU	405	Nuclear Reactor Engineering	(3-0) 3
PH	405	Introduction to Theoretical Physics	(3-0) 3
PH	411	Quantum Theory	(3-0) 3
PH	471	Solid State Physics	(3-0) 3
PH	565	Nuclear and Electron Spin Resonance Phenomena	(3-0) 3

SENIOR YEAR

Second Semester

CH	484	Elements of Radiochemistry	(3-3) 4
NU	306	Nuclear Instrumentation	(2-4) 3
NU	494	Nuclear Laboratory	(0-6) 2
		Three approved Electives	9
		Total credit hours	18

Technical Electives

MA	484	Probabilities	(3-0) 3
MA	526	Modern Algebra	(3-0) 3
NU	302	Radiological Health	(3-0) 3
NU	406	Nuclear Reactor Engineering	(3-0) 3
PH	412	Quantum Theory	(3-0) 3
PH	424	Introduction to Statistical Physics	(3-0) 3
PH	462	Nuclear Physics	(3-0) 3
PH	472	Solid-State Physics	(3-0) 3
PH	524	Low Temperature Physics	(3-0) 3

PAPER ENGINEERING

This curriculum has a hard core of chemical engineering subjects coupled with several in pulp and paper manufacture and the converting of paper. Emphasis is placed on the engineering and design aspects of this branch of engineering science. Graduates may go directly into industry or may continue with graduate studies either in Paper Engineering or in Chemical Engineering.

As the fifth largest industry in the United States, the paper industry offers employees both stability and excellent opportunities for advancement. The increasing complexity of pulp and paper operations and the growth of paper converting, involving plastics, chemicals, metals, and other materials, have created an intense and growing demand for men with sound engineering training and a basic knowledge of the industry. Graduates of the Paper Engineering course are qualified to enter the paper industry in research and development, production, sales and market development, or management.

The interest of the industry in Paper Engineering graduates is evidenced by the generous scholarships available to students enrolled in this program. Five four-year scholarships amounting to $2,000 for the four-year period are available, and other scholarships are granted based on individual scholastic records.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3) 4
CH	209	Analytical Techniques	(1-3) 2
CHE	203	Introduction to Chemical Engineering	(3-0) 3
LL	209	Technical Report Writing	(2-0) 2
MA	205	Calculus and Analytic Geometry	(4-0) 4
PH	205	Physics	(4-2) 4
		Total hours	(17-8) 19

Second Semester

CH	202	Organic Chemistry	(3-3) 4
CHE	204	Industrial Stoichiometry	(3-0) 3
EE	355	Electrical Controls and Power Circuits	(1 ½-1 ½) 3
LL	214	Introduction to American Literature	(3-0) 3
MA	206	Differential Equations	(3-0) 3
		Total hours	(15-4½) 16

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3) 4
CHE	303	Chemical Engineering I	(3-0) 3
CHE	311	Chemical Engineering Thermodynamics	(3-0) 3
ME	215	Analytic Mechanics I	(3-0) 3
PA	301	Engineering Analysis of Pulp Systems	(3-0) 3
PA	307	Analysis and Design of Testing *	(3-0) 3
		Total hours	(18-3) 19

* ROTC Students take AS 301.

Second Semester

CH	332	Physical Chemistry	(3-3) 4
CHE	304	Chemical Engineering II	(3-0) 3
ME	216	Analytic Mechanics II	(3-0) 3
PA	302	Engineering Analysis of Paper Systems	(3-0) 3
PA	308	Pulp and Paper Laboratory	(0-6) 2
		General Elective *	3
		Total credit hours	18

* ROTC Students take AS 302.

SENIOR YEAR

First Semester

CHE	405	Chemical Engineering III	(3-0) 3
CHE	411	Unit Operations Laboratory	(0-6) 2
CHE	313	Industrial Instrumentation *	(3-0) 3
EC	201	Economics I	(3-0) 3
PA	403	Engineering Analysis of Converting Processes	(3-0) 3
PA	405	Converting Laboratory	(0-6) 2
		Total credit hours	16

* ROTC Students take AS 401.

Second Semester

CHE	412	Unit Operations Laboratory	(0-6) 2
EC	202	Economics II	(3-0) 3
PA	410	Engineering Analysis of Paper Processing	(3-0) 3
		Technical Elective * or General Elective	3
		General Elective	3
		General Elective	3
		Total credit hours	17

* ROTC Students take AS 402.

PHYSICS

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.00 and no unremoved failures; in freshman physics and mathematics courses only, a cumulative average of 2.50 and no unremoved grades below C—. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

LL	261	Elementary Technical German	
or			
LL	263	Elementary French	
or			
LL	265	Elementary Technical Russian	(3-0) 3
MA	205	Calculus and Analytic Geometry	(4-0) 4
PH	205	Physics	(4-2) 4
PH	209	Problems in Physics	(1-0) 1
PH	257	Electric Circuits	(2-0) 2
PH	293	Laboratory Practice	(1-2) 1
		General Elective	(3-0) 3
		Total hours	(18-4) 18

Second Semester

EE	212	Introductory Electronics	(3-0) 3
LL	262	Elementary Technical German	
or			
LL	264	Elementary French	
or			
LL	266	Elementary Technical Russian	(3-0) 3
MA	206	Differential Equations	(3-0) 3
PH	242	Modern Physics	(3-2) 4
PH	258	Electrical Measurements	(1-3) 2
		General Elective	(3-0) 3
		Total hours	(16-5) 18

JUNIOR YEAR

First Semester

MA	301	Functions and Their Applications	(3-0) 3
PH	311	Intermediate Mechanics	(3-0) 3
PH	345	Atomic and Nuclear Physics	(3-0) 3
PH	353	Electromagnetic Theory	(3-0) 3
PH	393	Experimental Physics	(1-3) 1
		General Elective	(3-0) 3
		Total hours	(16-3) 16

Second Semester

MA	302	Functions and Their Applications	(3-0) 3
PH	312	Intermediate Mechanics	(3-0) 3
PH	346	Atomic and Nuclear Physics	(3-0) 3
PH	354	Electromagnetic Theory	(3-0) 3
PH	394	Experimental Physics	(1-3) 1
		General Elective	(3-0) 3
		Total hours	(16-3) 16

SENIOR YEAR

First Semester

PH	411	Quantum Theory	(3-0) 3
PH	493	Advanced Laboratory	(1-3) 2
		Experimental Elective	3
		Three Approved Electives	9
		Total credit hours	17

Experimental Electives

PH	443	Spectrographic Methods	(2-3) 3
PH	445	X-Ray Diffraction	(1-6) 3

Second Semester

PH	412	Quantum Theory	(3-0) 3
PH	494	Advanced Laboratory	(1-6) 3
		Experimental Elective	3
		Two Approved Electives	6
		Total credit hours	15

Experimental Electives

PH	448	Electron Microscopy and Electron Diffraction	(2-3) 3
PH	450	Infrared Radiation	(2-3) 3
PH	454	Piezoelectric Crystals	(2-3) 3

PLASTICS TECHNOLOGY

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics, and quality control augment the basic courses in mathematics, sciences, engineering, and plastics technology to round out a well balanced program.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the International Society of Plastics Engineers, an opportunity which affords each student member an early and rewarding professional association.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3) 4
CH	211	Quantitative Analysis	(3-3) 4
MA	205	Calculus and Analytic Geometry	(4-0) 4
PH	205	Physics	(4-2) 4
PL	201	Introduction to Polymeric Materials	(2-0) 2
		Total hours	(16-8) 18

Second Semester

CH	202	Organic Chemistry	(3-3) 4
CH	212	Qualitative Analysis	(3-0) 3
EE	355	Electrical Controls and Power Circuits	(1½-1½) 3
LL	314	Continental Literature Since the Renaissance	(3-0) 3
PL	202	Introduction to Polymeric Materials	(2-0) 2
		Elective *	(3-0) 3
		Total hours	(15½-4½) 18

* MA 206 Differential Equations recommended for advanced degree preparation.

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3) 4
*EC	201	Economics I	(3-0) 3
MA	383	Statistical Methods	(3-0) 3
ME	261	Machine Tool Laboratory	(1-2) 1
ME	313	Mechanics of Solids I	(3-0) 3
PL	301	Plastics Technology	(2-2) 3
		Total hours	(15-7) 17

* ROTC students will substitute AS 301.

Second Semester

CH	332	Physical Chemistry	(3-3) 4
*EC	202	Economics II	(3-0) 3
ME	374	Plastics Mold Design and Construction	(1-2) 1
ME	376	Materials Science	(3-2) 3
ME	378	Mechanics of Solids II	(3-0) 3
PL	302	Plastics Technology	(2-2) 3
		Total hours	(15-9) 17

* ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4) 4
ME	493	Industrial Instrumentation	(2-0) 2
PL	401	Plastics Technology	(2-3) 3
PL	403	Properties of Polymers	(0-3) 1
PL	411	Plastics Seminar	(1-0) 1
PL	413	Introduction to Polymer Physics	(2-0) 2
		Elective	(3-0) 3
		Total hours	(13-10) 16

Second Semester

CH	404	Chemistry of High Polymers	(3-4) 4
ME	382	Fluid Mechanics	(3-0) 3
PL	402	Plastics Technology	(2-3) 3
PL	404	Properties of Polymers	(0-3) 1
PL	412	Plastics Seminar	(1-0) 1
PL	414	Introduction to Polymer Physics	(2-0) 2
		Elective	(3-0) 3
		Total hours	(14-10) 17

Suggested Electives

CH	423-424	Advanced Organic Chemistry	(3-0)	(3-0) 6
IM	483	Statistical Quality Control		(3-0) 3
LL	261-262	Elementary Technical German	(3-0)	(3-0) 6
MA	206	Differential Equations		(3-0) 3

TEXTILE CHEMISTRY

The curriculum in Textile Chemistry is designed to provide a sound foundation in the basic principles of chemistry combined with a knowledge of chemical applications in the fiber and textile fields. Graduates are particularly prepared for positions in industrial organizations oriented toward chemicals for textile applications and fiber development and processing.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3) 4
CH	207	Electrolytic Solutions	(2-3) 3
CH	209	Analytical Techniques	(1-3) 2
MA	205	Calculus and Analytic Geometry	(4-0) 4
PH	205	Physics	(4-2) 4
TC	201	Introduction to Textiles	(2-0) 1
		Total hours	(16-11) 18

Second Semester

CH	202	Organic Chemistry	(3-3) 4
CH	210	Analytical Chemistry	(3-6) 5
MA	384	Statistical Methods	(3-0) 3
PH	206	Physics	(4-2) 4
TC	202	Chemistry and Physics of Fibers	(3-0) 3
		Total hours	(16-11) 19

JUNIOR YEAR

First Semester

CH	331	Physical Chemistry	(3-3) 4
EC	201	Economics I	(3-0) 3
TC	301	The Purification of Fibers	(2-3) 3
TC	311	Chemical Textile Testing	(3-0) 3
TE	471	Textile Evaluation	(2-3) 3
		General Elective	(3-0) 3
		Total hours	(16-9) 19

Second Semester

CH	332	Physical Chemistry	(3-3) 4
CH	334	Colloid Chemistry	(3-0) 3
CH	342	Organic Qualitative Analysis	(1-6) 3
EC	202	Economics II	(3-0) 3
		General Elective	(3-0) 3
		Technical Elective *	3
		Total credit hours	19

SENIOR YEAR

First Semester

CH	411	Advanced Analytical Chemistry	(2-4) 3
TC	403	The Principles of Dyeing and Printing	(2-6) 4
TC	411	Chemical Technology of Finishing I	(3-1) 3
		General Elective	(3-0) 3
		Two Technical Electives*	6
		Total credit hours	19

Second Semester

TC	404	Theory of Dyeing	(3-4) 4
TC	412	Chemical Technology of Finishing II	(3-2) 4
		General Elective	(3-0) 3
		Two Technical Electives*	6
		Total credit hours	17

* MA 206 is recommended as the technical elective in the junior year if graduate study is planned.

Technical electives in the senior year must include six credits selected from CH 423-424,* CH 431-432,* or CH 443-444.*

It is recommended that the remaining credits be taken in CH 403-404.

TEXTILE ENGINEERING

This course is based on a sound training in mathematics and science and their application to the solution of technical problems. The curriculum is similar to and related to that in Mechanical Engineering but includes sufficient subjects in textile science to qualify the student for positions in either production or research in the textile industry.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0) 3
EE	205	Basic Electrical Engineering Laboratory	(0-1½) 0
EE	211	Fundamentals of Electricity	(3-0) 3
MA	205	Calculus and Analytic Geometry	(4-0) 4
ME	215	Analytic Mechanics I	(3-0) 3
PH	205	Physics	(4-2) 4
		Total hours	(17-3½) 17

Second Semester

EC	202	Economics II	(3-0) 3
EE	206	Basic Electrical Engineering Laboratory	(0-1½) 1
EE	212	Introductory Electronics	(3-0) 3
MA	206	Differential Equations	(3-0) 3
ME	216	Analytic Mechanics II	(3-0) 3
ME	264	Metals Processes	(1-2) 1
TE	212	Fiber Science	(3-1) 3
		Total hours	(16-4½) 17

JUNIOR YEAR

First Semester

MA	355	Digital Computer Programming	(2-2) 2
MA	383	Statistical Methods	(3-0) 3
ME	311	Mechanics of Materials	(3-0) 3
ME	345	Thermodynamics	(3-0) 3
*ME	377	Elements of Materials Science	(2-0) 2
TE	363	Textile Systems I	(3-1) 3
		General Elective	(3-0) 3
		Total hours	(19-3) 19

* ROTC students will substitute AS 301.

Second Semester

EE	323	Electrical Energy Conversion	(3-2) 4
ME	314	Mechanical Engineering Laboratory II	(0-3) 1
*ME	346	Thermodynamics	(3-0) 3
ME	384	Fluid Mechanics	(3-0) 3
TE	364	Textile Systems II	(3-2) 3
TE	366	Textile Systems III	(2-1) 2
		General Elective	(3-0) 3
		Total hours	(17-8) 19

* ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

ME	394	Automatic Control Systems I	(3-0) 3
ME	415	Mechanical Engineering Laboratory III	(0-3) 1
ME	421	Machine Design	(2-3) 3
ME	445	Heat Transfer	(3-0) 3
TE	467	Textile Systems IV	2(-1) 2
TE	483	Engineering Design of Textile Structures	(3-0) 3
		General Elective	(3-0) 3
		Total hours	(16-7) 18

Second Semester

ME	416	Senior Project	(0-3) 1
TE	472	Textile Evaluation	(2-3) 3
TE	482	Application of Scientific Methods to Textile Processes	(3-0) 3
TE	484	Engineering Design of Textile Structures	(3-0) 3
		Two General Electives	(6-0) 6
		Technical Elective (Textile)	3
		Total credit hours	19

TEXTILE TECHNOLOGY

This course of study is designed to equip its students with a well-rounded understanding of the theory and principles relating to the processing of textile materials. At the same time it provides the scientific basis necessary to understand and apply this technological knowledge. Basic purpose of the program is to prepare students to become competent textile technologists for eventual supervisory, administrative, or executive positions within the industry and its allied fields. To achieve this end, a comprehensive course covers the basic theory, principles, and applications of the major phases of textile manufacture utilizing all the common fibers, both natural and man-made, and all fabricating processes.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0) 3
EE	211	Fundamentals of Electricity	(3-0) 3
EE	205	Basic Electrical Engineering Lab. 1	(0-1½) 0
MA	205	Calculus and Analytical Geometry	(4-0) 4
ME	215	Analytic Mechanics I	(3-0) 3
PH	205	Physics	(4-2) 4
		Total hours	(17-3½) 17

Second Semester

EC	202	Economics II	(3-0) 3
EE	212	Introductory Electronics	(3-0) 3
EE	206	Basic Electrical Engineering Lab. II	(0-1½) 1
ME	216	Analytic Mechanics II	((3-0) 3
ME	264	Metals Processes	(1-2) 1
TE	206	Textile Physics	(3-0) 3
TE	212	Fiber Science	(3-1) 3
		Total hours	(16-4½) 17

JUNIOR YEAR

First Semester

MA	355	Digital Computer Programming	(2-2) 3
MA	383	Statistical Methods	(3-0) 3
ME	377	Elements of Materials Science	(2-0) 2
TE	361	Technology of Yarns I	(3-1) 3
		Two General Electives	(6-0) 6
		Total hours	(16-3) 17

Second Semester

EE	323	Electrical Energy Conversion	(3-2) 4
ME	344	Heat & Power	(3-0) 3
ME	384	Fluid Mechanics	(3-0) 3
TE	362	Technology of Yarns II	(3-1) 3
TE	364	Textile Systems II	(3-1) 3
		General Elective	(3-0) 3
		Total hours	(18-4) 19

SENIOR YEAR

First Semester

ME	421	Machine Design	(2-3) 3
TE	435	Advanced Fabric Technology	(3-1) 3
TE	457	Technology of Finishing	(3-0) 3
TE	483	Engineering Design of Textile Structures	(3-0) 3
TE	485	Statistical Quality Control	(3-0) 3
		General Elective	(3-0) 3
		Total hours	(17-4) 18

Second Semester

TE	458	Technology of Finishing	(1-2) 2
TE	472	Textile Evaluation	(2-3) 3
TE	474	Instrumentation for Textiles	(2-2) 3
TE	484	Engineering Design of Textile Structures	(3-0) 3
TE	434	Technology of Knitting	(3-1) 3
		Technical Elective (textile)	3
		Total credit hours	17

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS	Aerospace Studies
BA	Business Administration
BI	Biology
CH	Chemistry
CHE	Chemical Engineering
EC	Economics
EE	Electrical Engineering
IM	Industrial Management
LL	Languages and Literature
MA	Mathematics
ME	Mechanical Engineering
NU	Nuclear Science and Engineering
PA	Paper
PH	Physics
PL	Plastics
SS	Social Sciences
TC	Textile Chemistry
TE	Textiles

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are restricted to graduate students. An asterisk following the subject number, e.g., PH 411-412*, indicates a subject which, although it is primarily for undergraduates, may ordinarily be taken for full graduate credit.

Odd numbers designate subjects offered in the first semester, even numbers designate subjects offered in the second semester. Hyphenated numbers indicate subjects continuing throughout the year.

Prerequisites are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6) 4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6) 6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

AEROSPACE STUDIES

AS 101-102 World Military Systems I and II (1-1) (1-1) 2

An introductory course exploring the causes of the present world conflict, the role and relationship of military power to the conflict, and the responsibility of an Air Force officer. The course begins with a discussion of the factors from which differing political philosophies have evolved. It continues with a tri-dimensional analysis of the three prime political philosophies which have guided segments of society in the twentieth century. This is followed by a discussion of the means that nations develop to pursue their objectives and how they confront each other in the use of these means. The course then treats individual military systems, with emphasis upon the U.S. Department of Defense and the U.S. Air Force.

AS 201-202 World Military Systems III and IV (1-1) (1-1) 2
[AS 101-102]

Continued study of world military forces and the political-military issues surrounding the existence of these forces. This includes a study of the United States Army and the United States Navy and their doctrines, missions, and employment concepts; a study of the military forces of NATO, CENTO, and SEATO and their roles in free world security; and an investigation of the military forces of the USSR, the Soviet Satellite armies, and the Chinese Communist Army. An analysis of the trends and implications of world military power.

AS 301-302 Growth and Development of Aerospace Power I and II (3-1) (3-1) 6

A survey course about the nature of war; development of airpower in the United States; mission and organization of the Defense Department; Air Force concepts, doctrine, and employment; astronautics and space operations; and the future development of aerospace power, including United States space programs, vehicles, systems, and problems in space exploration. The above areas are studied through the media of briefings, discussions, debates, and written reports by the student to improve his communicative skills.

AS 401-402 The Professional Officer I and II (3-1) (3-1) 6
[AS 301-302]

A study of professionalism, leadership, and management,

including the meaning of professionalism; professional responsibilities; the military justice system; leadership theory, functions, and practices; management principles and functions; problem solving; and management tools, practices, and controls. The above areas are studied through the media of discussions, briefings, and written reports by the student to improve his ability to communicate.

BUSINESS ADMINISTRATION

BA 141-142 Accounting I and II (2-2) (2-2) 6

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 241-242 Accounting III and IV (3-0) (3-0) 6

[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 Marketing Principles (3-0) 3

[EC 202 or EC 201 taken concurrently]

Analysis of modern methods of marketing and merchandising as they are related to consumer, producer, and middleman.

BA 322 Market Problems (3-0) 3

[BA 321]

[For students in Business Administration]

An analytic approach to marketing strategy in relation to the problems of organization, coordination, and control. Price policies, the government's role in marketing, and physical distribution.

BA 324 Industrial Marketing (3-0) 3

[BA 321]

[For students in Industrial Management]

Problems of marketing industrial goods. Distribution channels, price policies, product line planning, and marketing programs.

BA 325 Advertising (3-0) 3

[BA 321]

The relation of advertising to modern business organization and its place in marketing and distribution.

BA 326 **Marketing Research** **(3-0) 3**

[BA 321]

Measuring potential, design of experiments, data collection, sampling, questionnaires, study of promotional efforts, market testing, and controls.

BA 331 **Business Finance** **(3-0) 3**

[BA 142, EC 202]

Principles of financial management, including working and fixed capital, sources of funds, financial statements, budgeting and capitalization.

BA 332 **Money and Banking** **(3-0) 3**

[EC 201]

The role of money and monetary policy in the United States. The banking structure, the Federal Reserve System, other financial institutes, and international monetary systems.

BA 334 **Investment Management** **(3-0) 3**

[BA 331]

Principles of investment, including security analysis, portfolio management and market analysis.

BA 341-342 **Accounting V and VI** **(3-0) (3-0) 6**

Advanced accounting comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

BA 344 **Cost Accounting** **(2-2) 3**

[BA 142]

[For Accounting Majors]

Job lot, process, and standard cost systems, including joint and byproduct problems, and the managerial uses of cost data.

BA 346 **Managerial Accounting** **(2-2) 3**

[BA 142]

[For Non-accounting Majors]

The use of cost accounting from the point of view of the business manager. Job lot, process, and standard cost systems are utilized.

BA 362 **Business Law** **(3-0) 3**

The principles of commerical law, including contracts, agency, sales, partnerships, corporations, negotiable instruments, bailments and carriers, insurance, personal property, real property, suretyship and guarantees, and bankruptcy.

BA 371-372 **Production Management I and II** **(3-0) (3-0) 6**

The internal organization and productive process of the manufacturer, including the management functions of planning, directing, and administration in relation to production. Plant layout, materials handling, inventory control, quality control, and time and motion study systems.

BA 402 **International Business Operations** **(3-0) 3**

[EC 202]

The distinctive features of international commerce, including government policies, multinational corporate problems, foreign exchange, tax problems, and special licensing and agency arrangements.

BA 403 **Electronic Data Processing** **(3-0) 3**

The role of digital computers in the solution of management problems. The preparation and solution of sample problems on the Institute's IBM 1620 installation.

BA 421 **Procurement** **(3-0) 3**

[BA 321]

Purchasing procedure, quality control, inventory control, source selection, forward buying, and speculation, as applied to the industrial enterprise.

BA 423 **Marketing Management** **(3-0) 3**

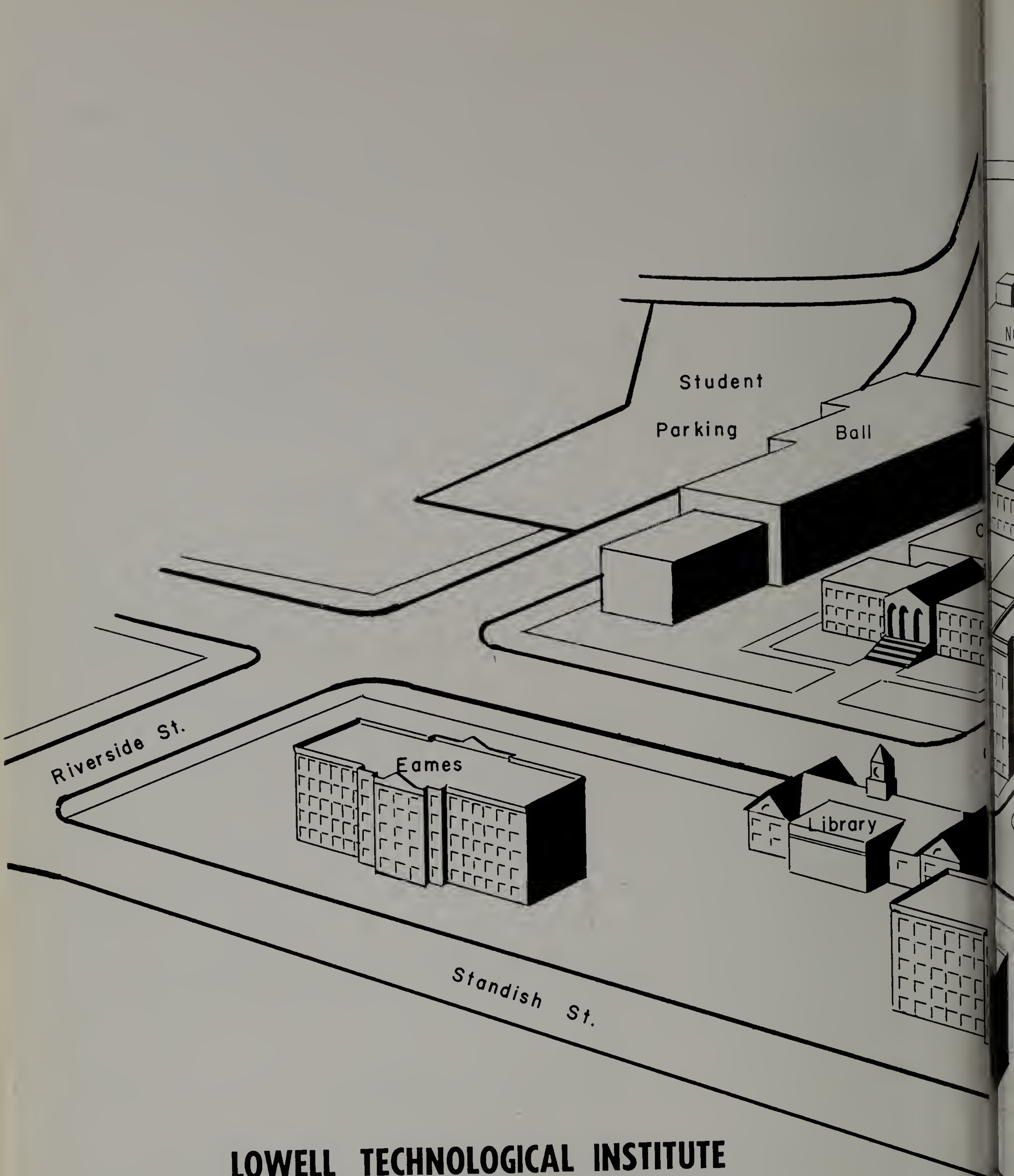
[BA 321]

Problems of marketing, especially from the point of view of the formulation of business policy.

BA 426 **Sales Management** **(3-0) 3**

[BA 321]

Management of the selling function in its broad aspect. Sales organization, compensation, selection, training, and supervision. Market research, product packaging and development, and distribution policies.



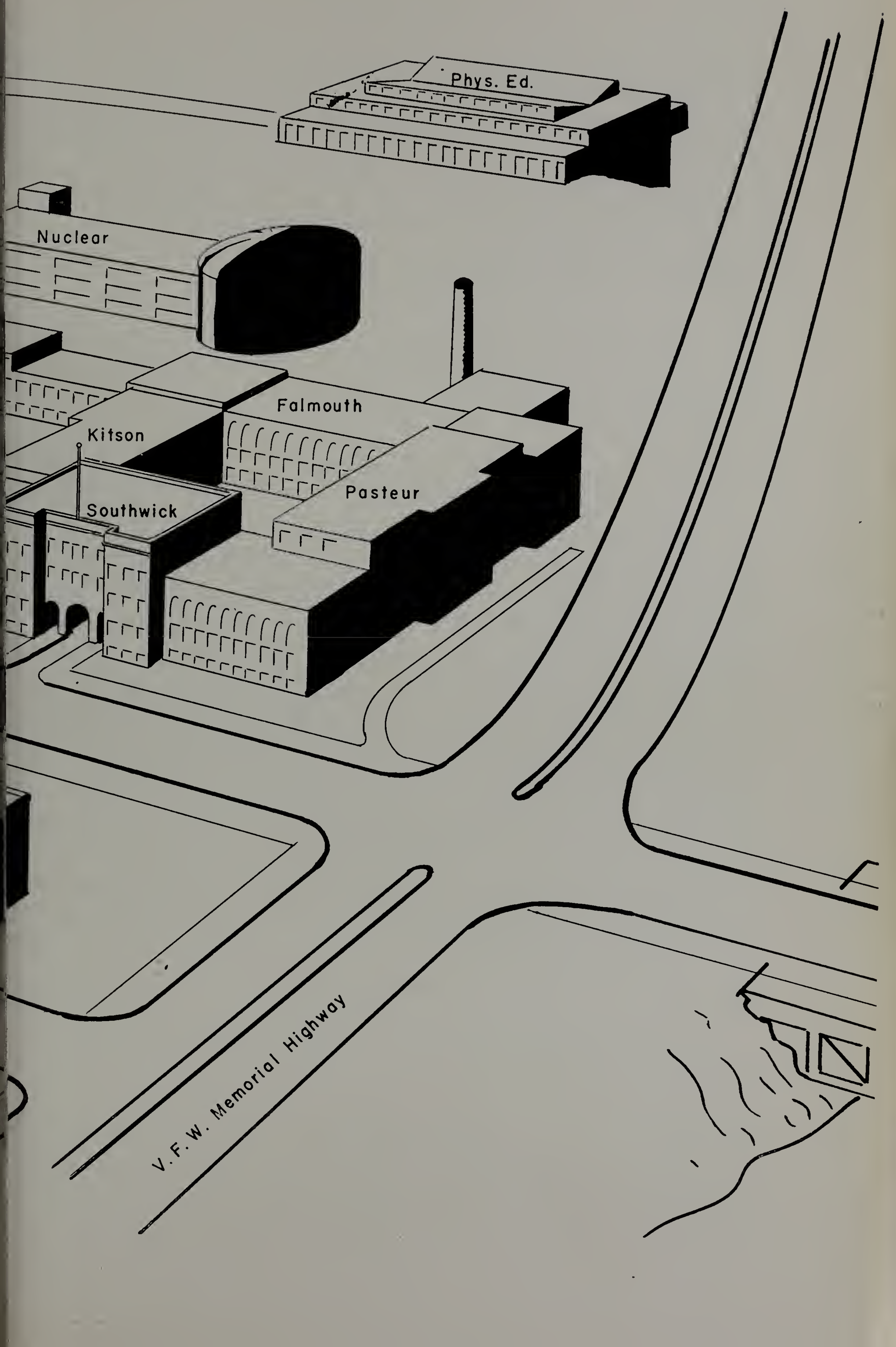
LOWELL TECHNOLOGICAL INSTITUTE
LOWELL MASSACHUSETTS

CLASSROOM DESIGNATION:

LETTER PREFIX REFERS TO BUILDING
FIRST NUMBER INDICATES FLOOR
HENCE, ROOM K-311 IS LOCATED IN KITSON HALL, 3rd FLOOR

BOOKSTORE: SECOND FLOOR, SOUTHWICK HALL.

DIVISION OF EVENING STUDIES OFFICE: BASEMENT, CUMNOCK HALL.


Phys. Ed.
Nuclear
Falmouth
Kitson
Pasteur
Southwick
V.F.W. Memorial Highway

BA 431 **Financial Management** (3-0) 3
[BA 331]

Advanced study of financial management principles. Emphasis on problem analysis and problem solving.

BA 441 **Auditing** (3-0) 3
[LBA 342]

Duties and responsibilities of the auditor, kinds of audits, programs of audit, and auditor statements and reports.

BA 444 **Accounting Systems** (3-0) 3
[BA 342]

Principles of system design; internal control, division of labor, routing of business papers, and procedural practices; systems modifications; and relationship of theory and practice of accounting to systems.

BA 445 **Tax Accounting** (3-0) 3
[BA 342]

Tax problems of partnerships, corporations, reorganizations, personal holding companies, trusts, gifts, and estates. Problems and interpretations of the internal revenue code and regulations of both the Federal and State agencies.

BA 451 **Personnel Management** (3-0) 3

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as employee health and safety, welfare, education, and wage and salary administration.

BA 452 **Industrial Relations** (3-0) 3
[BA 451]

Human interaction and group behavior in organized industrial settings. Interpersonal and intergroup conflict, motivation, and leadership. Case problems.

BA 481 **Insurance** (3-0) 3

Theory of risk, physical and moral hazards, types of insurance carriers, and basic features of each of the principal kinds of insurance.

BA 492 **Transportation** (3-0) 3

Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies of the United States.

BA 500 Research Seminar (3-0) 3

[Permission of Department Head]

Designed to give the better Business Administration student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

BIOLOGY

BI 101-102 **Introductory Biology** **(3-2) (3-2) 8**

A series of lectures and demonstrations designed to introduce the student to the principles and characteristics of living forms, with special reference to the cell and its metabolism and to the anatomy, physiology, and evolution of the major groups of the animal kingdom.

CHEMISTRY

CH 001-002 **Chemical Principles** (4-0) (4-0) 6

An introduction to the structure and reactivity of chemical species based on the periodic properties of the elements. Physical aspects of chemical theory are stressed and correlated.

CH 003-004 **Chemical Principles Laboratory** (0-2) (0-2) 2

The presentation of chemical principles in the form of concrete examples with illustration of the methods of an experimental science. Emphasis is placed on training in scientific observation, systematic recording of data and the derivation of conclusions from experimental results.

CH 105-106 **Introductory Chemistry** (3-2) (3-2) 8

[not open to Chemistry majors]

Selected topics of chemistry concerned with basic chemical principles as well as major industrial applications of inorganic chemistry.

CH 201-202 **Organic Chemistry** (3-3) (3-3) 8

[CH 002]

The classification, nomenclature, structure, mechanism of reaction, and behavior in bulk of important kinds of organic species. The laboratory work illustrates the experimental techniques which can be used to react, purify, characterize, and identify organic substances.

CH 206 **Qualitative Analysis** (3-0) 3

[CH 002]

[Primarily for students not majoring in chemistry]

A lecture course dealing with the physical chemistry of aqueous electrolytic solutions. The nature and behavior of solutes and solutions; reaction rate theory and its relation to solubility, proton transfer, and other types of equilibria; and application of the above principles to problems of separation and identification.

CH 207 **Electrolytic Solutions** (2-3) 3

[CH 002]

[Primarily for students majoring in chemistry]

An introduction to the physical chemistry of electrolytic

solutions, with emphasis on aqueous systems. Reactions involving ions, i.e., proton transfer, precipitation, complexation, and oxidation-reduction, studied rigorously both from a kinetic and an equilibrium approach. Extensive drill in calculations involving equilibrium constants of various types. The laboratory serves to investigate quantitatively some of the phenomena discussed in lectures.

CH 208 **Inorganic Chemistry** **(3-0) 3**

The chemical behavior, electronic and geometric structures, methods of preparation, reactions, and nomenclature of some of the more common elements and their compounds as well as some of the better-known transition and inner-transition elements. The laboratory deals with the preparation and study of some of the more interesting compounds.

CH 209 **Analytical Techniques** **(1-3) 2**

[CH 002]

The fundamentals of analytical techniques, including basic gravimetric and volumetric measurements and their calculations.

CH 210 **Analytical Chemistry** **(3-6) 5**

[CH 207 and CH 209]

[Primarily for students majoring in chemistry]

The fundamental principles of analytical chemistry, both qualitative and quantitative, including the separation, identification, and quantitative measurement of substances through chemical methods, chromatography, ion exchange, microscopy, fluorometry, and spectroscopy.

CH 211 **Quantitative Analysis** **(3-4) 4**

[CH 002]

[Primarily for students majoring in Plastics Technology]

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric and volumetric analysis, including some coverage of industrial applications.

CH 321 **Organic Chemistry Laboratory II** **(1-6) 3**

[CH 202]

A continuation of CH 202 laboratory involving additional laboratory work in organic chemistry with emphasis on modern techniques of synthesis.

CH 331 **Physical Chemistry** **(3-3) 4**

[CH 002, CH 206 or CH 207, MA 205]

Basic physical chemical approaches to studies of gases, laws of thermodynamics, solution properties, chemical and phase equilibria.

CH 332 **Physical Chemistry** **(3-3) 4**

[CH 331]

Basic physical chemical approaches to studies of kinetics, statistical mechanics, atomic and molecular structure, spectroscopy, and electrochemistry.

CH 334 **Colloid Chemistry** **(3-0) 3**

[CH 331 or equivalent]

Theoretical properties of the colloid system. Interfacial phenomena, particle kinetics, electrical properties, and viscosity characteristics are studied. The character of lyophobic and lyophilic sols, gels, and emulsions is developed from the above properties.

CH 342 **Organic Qualitative Analysis** **(1-6) 3**

[CH 202; CH 206]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 403-404 **Chemistry of High Polymers** **(3-4) (3-4) 8**

[CH 202, CH 332]

The physical and organic chemistry of monomers and polymers, including a consideration of non-bonding forces, spectroscopic methods of structure determination, structure and property correlations, fractionation, thermodynamics, and methods of molecular weight determination for polymers in solution; the kinetics of condensation and addition polymerization as applied to polymers and copolymers, mechanism of free radical and ionic polymerization, stereo-specific polymers, the chemistry of the more common polymer systems, and preparation of their corresponding monomers.

CH 407-408 **Advanced Studies in Chemistry** **Credits to be arranged**

[Permission of the Chairman of the Chemistry Division and the instructor]

Advanced work in analytical, organic, inorganic, physical, or textile chemistry, including literature survey, laboratory work, and reports.

CH 411* **Advanced Analytical Chemistry** **(2-4) 3**

[CH 211, CH 332]

Advanced analytical techniques based on physical-chemical principles and utilizing instrumental methods wherever applicable. The analytical use of complexes, radiant energy methods, electrochemistry, chromatography, polarography, analytical applications of radioisotopes, and physical methods of separation.

CH 423-424* **Advanced Organic Chemistry** **(3-0) (3-0) 6**

[CH 202]

Extension of first-year organic chemistry to include additional classes of compounds and special topics. Emphasis is placed on synthetic methods, including the mechanism, scope, and limitations of the important name reactions in the field of synthetic organic chemistry.

CH 431-432* **Advanced Physical Chemistry** **(3-0) (3-0) 6**

[CH 332 or equivalent]

An extension of introductory physical chemistry for undergraduate majors and first-year graduate students in chemistry and related fields, with emphasis on classical and statistical thermodynamics as they apply to the various chemical phenomena.

CH 443-444* **Advanced Inorganic Chemistry** **(3-0) (3-0) 6**

[CH 332]

A treatment of the structure and reactions of the inorganic elements and their compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics and the theory of the chemical bond, spectroscopy, inorganic stereochemistry, crystal field theory, reactions in nonaqueous solvents, coordination chemistry, and atomic structure, including the structure of the atomic nucleus.

CH 481* **Radiochemistry** **(3-3) 4**

[CH 002, MA 205, PH 205]

Fundamentals of radiochemistry, including radioactivity, atomic nuclei, nuclear reactions, reactors, and radiation detection and measurement, with emphasis on the use of radioactive materials in chemical applications. Designed primarily for majors in chemistry and in allied fields.

CH 484 **Elements of Radiochemistry** **(3-3) 4**

[CH 002]

A review of chemical principles as applied to radiochemistry, including coverage of such topics as radioactivity, nuclear

reactors, radiation chemistry, use of tracers in chemical application, and separation and study of fission products.

CH 501 Interpretation of Data (3-0) 3

Mathematical methods of analyzing, plotting, and interpreting experimental data. Lectures and exercises.

CH 502 Absorption Spectrophotometry and Color Measurement (2-3) 3

Theory and application of absorption spectrophotometry to the qualitative and quantitative analyses of chemical substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges, including theories of color, vision, and subjective color evaluation.

CH 503-504 Chemistry of High Polymers (3-0) (3-0) 6
[CH 202, CH 332]

An introduction to the physical and organic chemistry of high polymers for graduate students. Similar to CH 403-404 but with additional assigned reading.

CH 505-506 Techniques of Polymer Chemistry (0-4) (0-4) 2

A laboratory subject to be taken concurrently with CH 503-504 and designed to acquaint a graduate student majoring in Polymer Science with the techniques used in the preparation, characterization, and investigation of macromolecular substances.

CH 507-508 Chemistry Seminar (1-0) (1-0) 2

CH 512 Physical Chemistry of Surface-Active Agents (3-0) 3

A series of lectures on the physicochemical principles involved in the use of surface-active agents. The surface and bulk properties of the agents are studied and related to the over-all technical properties and uses.

CH 513 Chemical Applications of Spectroscopy and Spectrophotometry (3-0) 3

Theory, limitations, and applications of various types of spectroscopy to chemical research. Visible and ultraviolet, infrared, microwave, nuclear magnetic, and electron paramagnetic resonance spectroscopy. Emphasis is given to the interpretation of spectra, with some importance placed on analytical applications.

CH 514 Physicochemical Methods (2-0) 2

An outline of some of the more important physical methods of investigation and their applications to chemical research, including refractometry, polarimetry, microscopy, and chromatography (ion-exchange, adsorption, and gas).

CH 515 Advanced Laboratory Technique (1-3) 2

A study of the theory and application of the more advanced techniques and equipment in the preparation and purification of organic compounds, including high efficiency fractionation, vacuum and molecular distillation, hydrogenation and reactions in inert atmospheres.

CH 516 Chemical Literature (1-0) 1

Use of the chemical library, journals, reference works and other technical publications pertaining to chemical subjects. Exercises in finding assembling and using such data.

CH 517 Glass Working (0-1) 0

Fundamental techniques in the preparation and assembling of glass apparatus.

CH 521-522 Physical Organic Chemistry (3-0) (3-0) 6
[CH 424, CH 444]

Modern concepts of molecular structure developed and related to the physical and chemical properties of organic compounds. Polarization effects and reaction mechanisms considered in detail.

CH 527-528 Stereochemistry (3-0) (3-0) 6

The fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.

Offered in alternate years; offered in 1965-66.

CH 531-532 Statistical Mechanics for Chemists (3-0) (3-0) 6
[CH 539 or equivalent]

A continuation of the introductory statistical mechanics presented in CH 539. Current theories on such topics as configuration of polymer molecules, rubber elasticity, and solution structure, as well as principles of classical statistical mechanics.

CH 533-534 Quantum Mechanics for Chemists (3-0) (3-0) 6
[CH 539 or equivalent]

A continuation of the introduction to quantum mechanics in CH 539. Current theories on such topics as quantum mechanical treatment of crystalline solids, imperfect gases and liquids, and electromagnetic susceptibilities.

CH 535-536 Advanced Topics in Physical Chemistry (3-0) (3-0) 6

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 537 Chemical Thermodynamics (3-0) 3
[CH 539 or equivalent]

An advanced subject in chemical thermodynamics, with emphasis on the recent mathematical developments in the description of chemical systems and with attention given to current experimental methods of obtaining thermodynamic data. The chemical and physical scientific literature is used extensively.

CH 538 Rheology (3-0) 3

The general principles of the deformation and flow of matter under stresses studied qualitatively and quantitatively. Hookean and non-Hookean elasticity and Newtonian and non-Newtonian flow related to the properties of materials, especially in the field of high polymers.

CH 539 Theoretical Chemistry (3-0) 3
[CH 443-444 or equivalent]

The formal and group theoretical aspects of quantum chemistry particularly as they apply to molecular structure and reactivity.

CH 540 Chemical Kinetics (3-0) 3
[CH 432 or equivalent]

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanism, collision theory, and absolute rate theory.

CH 541-542 Graduate Thesis Credits to be arranged

An independent investigation of a problem by the student

in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

CH 551-552 Physical Chemistry of Macromolecules (3-0) (3-0) 6
[CH 404, CH 432]

An advanced treatment of the physical chemistry of macromolecules, including methods available for molecular structure determination. Consideration of the thermodynamic and statistical approaches to the theory of high-polymer solutions, with particular emphasis on molecular weight dependencies and a study of the kinetics of polymerization and depolymerization.

Offered in alternate years; not offered in 1965-66.

CH 553 Organic Chemistry of Macromolecules (3-0) 3
[CH 403, CH 424]

An advanced study in polymer science concerned with modern theoretical concepts and including mechanisms of formation and degradation of macromolecules.

Offered in alternate years; offered in 1966-67.

CH 554 Stereochemistry of Macromolecules (3-0) 3
[CH 404, CH 424]

Stereochemical factors affecting the formation and properties of macromolecules.

Offered in alternate years; offered in 1966-67.

CH 555 Polymer Physics (3-0) 3

A general treatment of the physical behavior of high-polymer systems. Lectures cover microscopic structure, including the structure of polymer molecules, intermolecular forces, first- and second-order transitions and macroscopic behavior including rheology and mechanical behavior, the kinetic theory of rubber elasticity, electrical, optical, and thermal properties. Comparisons are made with other classes of materials from time to time to emphasize the unique properties of high polymers.

Offered in alternate years; offered in 1966-67.

CH 556 Physical Chemistry of Surfaces (3-0) 3

Energetics of surfaces, adsorption, monolayers and films, electrical aspects of surface chemistry, and reactions at interfaces.

Offered in alternate years; offered in 1966-67.

CH 561-562 Advanced Organic Synthesis (3-0) (3-0) 6
[CH 423-424 or equivalent]

The application of known organic reactions to the synthesis of chemical species in such fields as the terpenes, steroids, alkaloids, antibiotics, and selected heterocyclic derivatives.

Offered in alternate years; offered in 1966-67.

CH 564 Organic Qualitative Analysis (1-6) 3

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 566 Heterocyclic Chemistry (3-0) 3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years; not offered in 1966-67.

CH 567 Steroid Chemistry (3-0) 3

The chemistry of important classes of steroids with emphasis on both chemical and physical methods of structure determination.

CHEMICAL ENGINEERING

CHE 203 Introduction to Chemical Engineering (3-0) 3

[CH 002, MA 108]

Introduction to fundamentals of chemical engineering; curve plotting; elements of kinetics and chemical equilibria; development of Flow Sheets; introduction to material balances.

CHE 204 Industrial Stoichiometry (3-0) 3

[CHE 203, MA 206 taken concurrently]

Material balances and energy balances, including phase separation and thermochemistry and their applications to chemical engineering processes. Development of unsteady-state concepts.

CHE 303 Chemical Engineering I (3-0) 3

[CHE 204]

Unit operations of fluid flow, mixing, materials handling, size reduction and separation, and filtration processes.

CHE 304 Chemical Engineering II (3-0) 3

[CHE 303]

Unit operations of heat transfer, evaporation and mass transfer.

CHE 311 Chemical Engineering Thermodynamics (3-0) 3

[CHE 303 taken concurrently]

Application of the first and second laws of thermodynamics to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature; fugacity and activity; state properties; homogeneous and heterogeneous equilibria; electrochemical effects.

CHE 313 Industrial Instrumentation (3-0) 3

[CHE 203, PH 205]

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level and fluid flow; response characteristics of mechanical, electric and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

CHE 405 Chemical Engineering III (3-0) 3
[CHE 304]

Unit operations of gas absorption, distillation and extraction, leaching and crystallization, air/water contact processes and drying.

CHE 407 Engineering Analysis of Chemical Processes (3-0) 3
[CHE 405 taken concurrently]

A qualitative and quantitative analysis of selected chemical processes from a chemical engineering and economic standpoint Analysis of material and heat balances, equilibria, kinetics, flow sheets, and economic factors. Report and plant visits.

CHE 408 Engineering Materials (3-0) 3

Discussion of materials for engineering purposes from the standpoint of physical and chemical structures, corrosion, economics and end use requirements. Corrosion principles, structures of metals, polymeric materials and non-metallic inorganic materials.

CHE 410 Process Analysis and Design (3-0) 3
[CHE 405]

Economic principles applied to the evaluation and optimization of various chemical engineering processes. Several minor projects and a major design problem requiring written reports provide practical application of the various engineering and economic principles.

CHE 411-412 Unit Operations Laboratory (0-6) (0-6) 4
[CHE 405 taken concurrently]

Experimental studies and projects involving various unit operations. Both individual and group projects. Written and oral reports are required.

CHE 501-502 Graduate Thesis Credits to be arranged

Every graduate student is required to write a thesis on original research work done under the supervision of a senior staff member, and this thesis must be approved by an examining committee appointed by the Department Head.

CHE 503 or 504 Absorption and Extraction (3-0) 3
[CHE 405, CHE 410]

Principles of separation; phase diagrams and multicomponent mixtures; mathematical and graphical solutions to mass transfer problems.

CHE 505 or 506 Colloid Chemistry for Chemical Engineers (3-0) 3

Colloid principles applied to chemical engineering problems; zeta potential and applications; specific problems involving surface chemistry and physics; mathematics of colloidal systems.

CHE 507 Corrosion and Electrochemical Principles (2-0) 2

Electrochemical principles and physical chemistry relating to the corrosion of metals. Materials of construction and design based on these principles.

CHE 509 Mathematics for Chemical Engineers (2-0) 2

[CHE 405, MA 206]

Application of mathematics to chemical engineering problems; unsteady state equations and problems; special graphical solutions; analysis of specific real problems.

CHE 511 or 512 Structure and Properties of Matter (3-0) 3

Fundamental properties of matter as they relate to chemical engineering problems. Materials of construction. Rheological properties of polymeric materials and their application to chemical engineering.

CHE 513 Advanced Economic Balance (3-2) 4

Detailed study of several processes from the standpoint of optimization and economics of design. Group design of a specific chemical plant. Use of computers in solutions of design problems.

CHE 517 or 518 Advanced Distillation (3-0) 3

[CHE 504]

Review of principles of distillation and phase separation; application to multicomponent distillation. Design of columns; analysis of specific systems, and plate design.

CHE 523 or 524 Advanced Chemical Process Analysis (3-0) 3

[CHE 405, CHE 407]

Detailed study of several commercial processes from the standpoint of engineering principles and economics. Economics and interrelationships of the chemical industry. Analysis of specific real problems. Factors involved in determination of best design from several alternatives.

CHE 525 or 526 Advanced Heat Transfer (3-0) 3
[CHE 405]

Review of principles of energy transport. Specific problems in convection and radiant heat transfer. Mathematical treatment of unsteady-state heat transfer.

CHE 530-531 Chemical Engineering Seminar (1-0) (1-0) 2

CHE 532 or 533 Applications of Computers (2-3) 3

Solutions to several chemical engineering designs and analysis by use of digital computer. Development of simple mathematical models for operations.

ECONOMICS

EC 201 **Economics I** **(3-0) 3**

The foundations and nature of economic principles. National income, money and banking, and monetary and fiscal policy.

EC 202 **Economics II** **(3-0) 3**
[EC 201]

Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 211-212 **Economic Statistics I and II** **(3-0) (3-0) 6**

Basic concepts of statistical methods. Topics covered include measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 **Economic Development of the United States** **(3-0) 3**

The background of the present economic system and an intensive study of the influence of science and technology upon our economic development.

EC 302 **Labor Economics** **(3-0) 3**
[EC 202]

The effect of the operation of American capitalism upon the position of labor. Analysis of the rise of union organization and the factors in its growth. Consideration of trends in the labor forces, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 **Microeconomic Theory** **(3-0) 3**
[EC 202]

An advanced examination of price and production theory. The theory of the household and the firm.

EC 304 **Macroeconomic Theory** **(3-0) 3**
[EC 202]

An analysis of Keynesian and post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 402 **Government and Business** **(3-0) 3**

[EC 202]

An examination of federal, local, and state controls on business activity, with emphasis on the economic interpretation of the various statutes and court decisions involving business.

EC 403 **International Trade Theory** **(3-0) 3**

[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 404 **Comparative Economics Systems** **(3-0) 3**

[EC 202]

Income distribution and resource allocation in centrally-planned as opposed to market-oriented economics. Emphasis on output decisions, role of price, problems of consistency and efficiency, success indicators, and incentives.

EC 407 **Introduction to Econometrics** **(3-0) 3**

[EC 202, 212]

The course will provide the student both theoretical and empirical knowledge of econometrics. The student will be presented with methods of handling data, quantitative empirical estimates, and tests of economic theory in the forms actually used in economic research.

EC 408 **History of Economic Thought** **(3-0) 3**

[EC 303]

Analysis of the development of economic theory; emphasis on the rise of classical economic thought.

EC 412 **Managerial Economics** **(3-0) 3**

[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis, and competitive action.

EC 414 **Engineering Economy** **(3-0) 3**

[EC 202, or permission of instructor]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

ELECTRICAL ENGINEERING

EE 201-202 Introductory Circuit Theory (4-0) (4-0) 8

[MA 108 and PH 104; MA 205 and 206 taken concurrently]

An introduction to the study of the mathematical and physical aspects of electric circuits in which radiation in the form of electromagnetic waves does not play a major role. Kirchhoff's laws, Thevenin's theorem, reciprocity of simple circuits, vector diagrams, vector algebra, sinusoidal steady-state behavior of simple circuits, transients in alternating-current circuits, and coupled circuits.

EE 205-206 Basic Electrical Engineering Laboratory (0-3/2) (0-3/2) 1

Experimental work designed to acquaint the student with electrical instruments and the techniques of electrical measurements and to provide experimental verification of the behavior of passive electrical circuits.

EE 211 Fundamentals of Electricity (3-0) 3

[PH 104; MA 205 taken concurrently]

An introduction to electric circuits for students not majoring in Electrical Engineering but who have a background in basic principles of electricity and magnetism. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state a.c. circuits, two-terminal networks, and two-terminal-pair networks.

EE 212 Introductory Electronics (3-0) 3

[EE 211, MA 205]

A background subject in electronics for students not majoring in Electrical Engineering, presenting the properties and uses of vacuum tube and semiconductor devices.

EE 301-302 Electronic Devices/Models (4-0) (4-0) 8

[EE 202, MA 206]

Basic concepts, techniques, and methods of analysis of electronic devices, with particular emphasis on the break-point method, piecewise linearization, and active circuit theory. Diode operation, rectification, amplification, and RC/RL wave-shaping. Single-stage, multistage, power, and tuned amplifiers discussed with consideration of gain, band-width, and frequency response.

EE 306 **Electromagnetic Theory** **(4-0) 4**

[MA 311]

Electricity and magnetism presented from the field theory point of view, using vector analysis and Maxwell's equations. The static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials; time-changing electric and magnetic fields, magnetic induction, electromagnetic waves and energy flow, and boundary value problems.

EE 309-310 **Electronic Devices Laboratory** **(0-3 (0-3) 2**

[EE 206, EE 301-302 and EE 315 taken concurrently]

An intermediate laboratory course in which the experiments are designed to stimulate an appreciation for and a realization of the limitations of basic electronic equipment. The experiments are closely coordinated with the allied concurrent courses and provide experimental verification of the principles of electronic devices and circuits.

EE 314 **Digital Computers— Applications and Programming** **(2-2) 3**

[EE 202]

The physical principles and instrumentation of digital computers and their application to problems in science and engineering. Programming methods and techniques.

EE 315 **Network Analysis** **(4-0) 4**

[EE 202, MA 206]

Complete solutions of linear passive networks; power and energy associated with arbitrary excitation functions; Fourier and Laplace transformations and a comparison of network analysis by these methods with the classical differential equation approach; numerical evaluation methods using impulse train techniques; and convolution in the time and frequency domain. Selected topics from the theory of determinants, matrices, linear transformations and quadratic forms and functions of a complex variable emphasizing the basic aspects for analysis problems.

EE 323 **Electrical Energy Conversion** **(3-2) 4**

[EE 211, MA 205]

The generation, control, utilization, and conversion of electrical energy.

EE 351 **Industrial Electronics** **(3-0) 3**

[MA 108, PH 104]

[Not open to students majoring in Electrical Engineering, Mechanical Engineering, Physics, or Textile Engineering]

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum- and gaseous-tube characteristics and of circuits containing such tubes for the purpose of rectification, amplifications and oscillation; and industrial photoelectric and time delay relays.

EE 355 **Electrical Controls and Power Circuits** **(1½-1½) 3**

[Not open to students majoring in Electrical Engineering]

Power requirements in single-phase and three-phase power circuits; operating characteristics of various types of direct-current and alternating-current motors and generators; manual and automatic electric controls including photoelectric relays, time delay relays, and motor control. Laboratory Workshop.

EE 401-402* **Feedback Control Systems and Their Components** **(3-0) (3-0) 6**

[EE 202, MA 311]

The various methods of analysis and design of feedback control systems, including the time-domain, frequency-domain, and root-locus approaches. Some coverage of control system components is included.

EE 403-404 **Microwave Electronics** **(3-0) (3-0) 6**

[EE 315, MA 311]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, generation and focusing of high-current electron beams with electric and magnetic fields, electron optics, velocity modulation, space charge wave propagation and traveling wave interaction with electron beams with application to microwave amplifiers and oscillators, and antennas.

EE 409-410 **Applied Electronics Laboratory** **(0-4) (0-4) 4**

[EE 310]

The purpose of this subject is to give the student an experimental familiarity with the nature, application, and performance of various electronic devices. Emphasis is given to methods of electrical measurement and the preparation of good technical reports.

EE 411-412 Logical Design of Digital Computers (3-0) (3-0) 6
[EE 302]

Foundations for the complete design of digital computer subsystems, such as arithmetic unit, computer memory, control, and input-output equipment with emphasis on basic circuitry as well as the logical tools: flip-flops, shift-register, logical gates, and magnetic core memories. Boolean algebra, systems synthesis, coding, and error detection.

EE 415-416* Electronic Amplifier Circuits (3-0) (3-0) 6
[EE 302, MA 311]

An integrated treatment of the analysis and design of vacuum tube and transistor amplifier circuits with emphasis on the design of such circuits. The majority of circuits considered are of the small-signal category, i.e., Class A operation.

EE 423 Analog Computer Technology (1½-1½) 3
[EE 302, MA 311]

Logical structure of analog computers; methods of problem preparation; study of computer components, input and output devices. Lectures and laboratory workshop.

EE 425-426* Wave Shaping and Generation (3-0) (3-0) 6
[EE 302, MA 311]

Principles and methods of wave shaping and wave generation using active and passive elements. Timing, switching, memory devices, oscillations, and wave shaping. Free use is made of piecewise-linear approximation, the break-point method, and/or the assumed diode state in conjunction with linear network theory. Particular emphasis is given to model representation and its analysis.

EE 429-430 Network Synthesis (3-0) (3-0) 6
[EE 315, MA 311]

A review of methods of analysis useful in the study of signals, systems, and their response; impedance and admittance properties relating the frequency and time domain aspects of physical circuit behavior; linear passive network theory, emphasizing the synthesis aspects; fundamental works of Foster, Cauer, Brune, Darlington, and Guillemin applied to design of networks having a prescribed driving-point and transfer characteristics; synthesis of coupling networks for prescribed transfer characteristics, including RC, RLC, and minimum-phase and nonminimum-phase types; real part sufficiency and related topics; and Fourier, Laplace, and Hilbert transforms.

EE 431-432 Special Topics in Electronics (3-0) (3-0) 6

An analytical consideration of special topics of importance in the field of electronics.

EE 433-434 Electro-Optical Analogues (3-0) (3-0) 6
[EE 302, EE 315, MA 311]

A review of linear system analysis, including Fourier analysis, as applied to the analysis of linear electrical and optical systems, with emphasis on the similarities of the two classes of systems.

EE 501-502 Applied Statistics (3-0) (3-0) 6

Consideration of electromagnetic waves in physical media by statistical analysis methods.

EE 503-504 Solid-State Physical Electronics (3-0) (3-0) 6

A physical interpretation of the properties of materials in terms of their dielectric constant, magnetic permeability, and electrical conductivity; dielectric, ferroelectric, and piezoelectric materials; diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic materials; metals, semiconductors, and insulators; and applications to electrical engineering devices.

EE 505-506 Microwave Electronics (3-0) (3-0) 6

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and traveling wave tubes.

EE 509-510 Transients in Electromechanical Systems (3-0) (3-0) 6

Training in the formulation and solution of ordinary and partial differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems, with extensive use of modern operational mathematical techniques.

EE 511-512 Dynamic Control Analysis (3-0) (3-0) 6

The principles of electronic devices used for control and measurement in applied science and engineering.

EE 513-514 Electromagnetic Theory (3-0) (3-0) 6

Maxwell's equations, static and time-varying fields of charges and currents, energy and momentum relations, the wave equation, Poynting's vector, waveguides, special theory of relativity, retarded fields, radiation from accelerated charges and antennas, interaction of charged particles, and electromagnetic fields.

EE 529-530 Network Synthesis (3-0) (3-0) 6

The formulation of the fundamentals of network theory; establishing realizability conditions and synthesis techniques for various classes of networks and network functions; and methods for realizing one or more networks whenever a function of the given class is prescribed.

EE 531-532 Seminar in Electronics (1-0) (1-0) 2

Discussion by staff members and students of current journal publications and topics of current interest in electronic science, electronic engineering, and related areas of applied physics.

EE 533-534 Special Problems in Electronics Credits to be arranged

An opportunity for individual study, under the direction of a staff member, of topics in or related to electronic engineering.

EE 535-536 Graduate Research Credits to be arranged

Supervised research and thesis on some problem in electronic science, electronic engineering, or certain areas of applied physics.

INDUSTRIAL MANAGEMENT

IM 351 — Motion and Time Study — (0-2) 1

The application of methods improvement and work measurement techniques. The use of the stop watch, work sampling, and operator charts in terms of application to standard systems such as M.T.M. and Work Factor.

IM 371 — Systems Engineering and Operations Research — (3-0) 3

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 483 — Statistical Quality Control — (3-0) 3

[MA 383 or 384 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 494 — Management of Computer Operations — (3-0) 3

The use of digital computers in management problems. Programming of work on the Institute's 1620 computer installation.

IM 500 — Research Seminar — (3-0) 3

[Permission of Department Head]

An opportunity for the advanced Industrial Management student to do research in an area of special interest under the direction of a member of the department.

LANGUAGES AND LITERATURE

LL 109-110 English for International Students (3-0) (3-0) 6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 English I and II (3-0) (3-0) 6

Introduction to literature through the essay, non-dramatic prose fiction, poetry, and drama. Critical papers.

LL 209 Technical and Scientific Communication (2-0) 2

Training in the theory, design, and organization of reports in science and industry. Preparation of written and oral reports for specific scientific and technical problems.

LL 213 Introduction to English Literature (3-0) 3

[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English literature.

LL 214 Introduction to American Literature 3-0) 3

[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American literature.

LL 233 Comparative Literature (3-0) 3

[LL 111-112]

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 Shakespeare (3-0) 3

[LL 111-112]

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 261-262 Elementary Technical German (3-0) (3-0) 6

An introduction to the study of the German language to develop a reading knowledge of scientific German. Limited practice in pronounciation and writing. No credit for the first semester without the second.

LL 263-264 Elementary French (3-0) (3-0) 6

An introduction to the study of the French language to develop a reading knowledge. Limited practice in pronunciation and writing. No credit for the first semester without the second. For students who have had less than two years of secondary-school training in French.

LL 265-266 Elementary Technical Russian (3-0) (3-0) 6

An introduction to the study of the Russian language to develop a reading knowledge of scientific Russian. Limited practice in pronunciation and writing. No credits for the first semester without the second.

LL 267-268 Elementary Spanish (3-0) (3-0) 6

An introduction to the study of the Spanish language to develop a reading knowledge. Limited practice in pronunciation and writing. No credit for the first semester without the second. For students who have had less than two years of secondary-school training in Spanish.

LL 313 Introduction to Continental Literature (3-0) 3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers through the Renaissance.

LL 314 Continental Literature Since the Renaissance (3-0) 3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers of the Neoclassic through the modern period.

LL 333 Problems of Philosophy (3-0) 3
[LL 111-112]

An introduction to some of the persistent problems of ethics and metaphysics and the solutions offered by modern thinkers.

LL 363-364 Intermediate French (3-0) (3-0) 6
[LL 264 or equivalent]

Intended to increase reading knowledge and provide further training in speaking and writing. May be taken by students who have had two or more years of secondary-school training in French.

LL 365-366 **Intermediate Literary and Conversational Russian** **(3-0) (3-0) 6**

[LL 266]

Intended to increase reading knowledge and to provide practice in speaking and writing. Russian essays and short stories of moderate difficulty with explanatory notes and vocabulary.

Offered in alternate years; not offered in 1965-66.

LL 367-368 **Intermediate Literary and Conversational German** **(3-0) (3-0) 6**

[LL 262]

Intended to increase reading knowledge and to provide practice in speaking and writing. German essays and short stories of moderate difficulty with explanatory notes and vocabulary.

LL 369-370 **Intermediate Spanish** **(3-0) (3-0) 6**

[LL 268 or equivalent]

Intended to increase reading knowledge and provide further training in speaking and writing. May be taken by students who have had two or more years of secondary-school training in Spanish.

LL 436 **English Romanticism** **(3-0) 3**

[LL 111-112]

A close study of the central works of Wordsworth, Coleridge, Blake, Byron, Shelley, and Keats, with emphasis on the sensibility peculiar to the poetic and philosophical attitudes of these writers.

LL 465 **Advanced Seminar in Literary Russian** **(3-0) 3**

[LL 366]

Directed study in Russian fiction. Seminar reports on assigned topics are given in Russian every week by each student, orally or in written form as directed.

Offered in alternate years; offered in 1965-66.

LL 466 **Advanced Seminar in Literary Russian** **(3-0) 3**

[LL 366]

Directed study in Russian nonfiction. Seminar reports on assigned topics are given in Russian every week by each student, orally or in written form as directed.

Offered in alternate years; offered in 1965-66.

LL 467 Advanced Seminar in Literary German (3-0) 3
[LL 368]

Directed study in the works of two classical and two modern German writers. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

Offered in alternate years; offered in 1965-66.

LL 468 Advanced Seminar in Literary German (3-0) 3
[LL 368]

Directed study in the works of leading German authors, primarily in the field of nonfiction. Seminar reports of an analytical nature on assigned topics (stylistic methods, social philosophy of the author, etc.) are given in German every week by each student, orally or in written form as directed.

Offered in alternate years; offered in 1965-66.

LL 471 The Modern American Novel (3-0) 3
[LL 111-112]

A consideration of the outstanding American novelists from 1920 on. Selected works of Faulkner, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0) 3
[LL 111-112]

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 World Drama (3-0) 3
[LL 111-112]

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 Modern Drama (3-0) 3
[LL 111-112]

An analysis of major forces in drama from the time of Ibsen to present. Selected representative plays are read and discussed.

LL 476 **Nineteenth-Century British Novel** **(3-0) 3**

[LL 111-112]

The dominant literary form of the period studied in a representative novel of each of the major novelists from Scott to Eliot, including Austen, Dickens, Thackeray and Emily Bronte.

LL 482 **The American Short Story** **(3-0) 3**

[LL 111-112]

A critical survey of the growth and development of the American short story. Consideration of the works of Poe, Crane, Anderson, and others.

MATHEMATICS

MA 101 Mathematical Analysis I (3-0) 3

Review of algebra, factoring, rectangular coordinates, functions and graphs, linear equations, exponents and radicals, quadratic equations, inequalities, variation, mathematical induction, progressions, approximate numbers, logarithms, mathematics of investment, trigonometric functions of acute angles, solution of right triangles, and logarithmic solution of right triangles.

MA 102 Mathematical Analysis II (3-0) 3
[MA 101]

Trigonometric functions of any angle, solution of oblique triangles, trigonometric formulas and identities, radian measure, trigonometric curves, trigonometric equations, complex numbers, polynomials, equation and locus, straight line, circle, parabola, ellipse, hyperbola, curve sketching, parametric equations, curve fitting, permutations and combinations, probability and determinants.

MA 107 Calculus and Analytic Geometry (4-0) 4

Functions and graphs, equations of straight lines, the differentiation and integration of algebraic functions together with applications involving related rates, differentials, maxima and minima, Mean Value Theorem, areas, volumes, lengths of curves, areas of surfaces of revolution, center of mass, the theorems of Pappus, pressure, and work.

MA 108 Calculus and Analytic Geometry (4-0) 4
[MA 107]

The differentiation of exponential, logarithmic, and trigonometric functions; integration by parts, integration by partial fractions, integration by trigonometric substitution, and other integral forms; determinants, both second and higher order; properties of roots of higher-degree equations; the conics; translation and rotation of curves, hyperbolic and inverse hyperbolic functions, polar coordinates, parametric equations, differentiation of vectors, and tangential and normal components of velocity and acceleration.

MA 201 **Mathematical Analysis III** (3-0) 3

[MA 102]

Sets, set operations, logical statements, Boolean algebra, decision making bodies, binary arithmetic, digital computers (design and operation), functions and managerial planning, functions and their use in economics and business, and mathematics of investment and finance.

MA 202 **Mathematical Analysis IV** (3-0) 3

[MA 201]

Linear programming with graphs and ordinary algebra, vector algebra and matrix algebra used in linear programming, simplex method, transportation method, differential calculus, limit concept and continuity of a function, integral calculus and applications of calculus in business operations.

MA 205 **Calculus and Analytic Geometry** (4-0) 4

[MA 108]

The scalar and vector products of two or more vectors, solid analytic geometry, space curves, curvature, arc length, partial differentiation, directional derivatives, gradient, chain rule, total differential, the method of least squares, maxima and minima of independent variables, line integrals, multiple integration, and three-coordinate systems; series, including Maclaurin, Taylor, and Fourier series, indeterminate forms, and test for convergence; and complex functions including the Argand diagram, DeMoivre's theorem, the Cauchy-Riemann equations, and logarithmic functions.

MA 206 **Differential Equations** (3-0) 3

[MA 205]

The solution of ordinary differential equations and of partial differential equations of the first order and first degree and of forms in certain other orders and other degrees that lend themselves readily to solution. Practical applications to chemistry and engineering.

MA 221-222 **Linear Algebra** (3-0) (3-0) 6

Basic properties of the real and complex number systems. Introduction to groups, rings, fields. Linear transformations and matrices in finite dimensional vector spaces. Inner products. Applications to geometry.

MA 301-302 Functions and Their Applications (3-0) (3-0) 6

[MA 206]

Ordinary differential equations, the Laplace transformation, numerical methods of solving differential equations, series solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, topics in higher-dimensional calculus, partial differential equations, partial differential equations of mathematical physics, and complex variable theory.

MA 305 or 306 Theory of Equations (3-0) 3

[MA 108]

Mathematical induction, complex numbers, integral and rational roots, solution by radicals, impossibility of certain geometrical constructions, number of real roots, isolation of a root, determinants, and approximate methods of solution.

MA 307-308 Advanced Calculus (3-0) (3-0) 6

[MA 206]

[For students majoring in Mathematics]

Functions of several real variables. Calculus of vectors and differential forms. Introductory functional analysis and differential equations.

MA 311 Engineering Mathematics (3-0) 3

[MA 206]

[For students majoring in Electrical Engineering]

Vector analysis, complex variable theory, ordinary differential equations, Laplace transformation, and numerical methods of solving differential equations.

MA 312 Engineering Mathematics (3-0) 3

[MA 311]

[For students majoring in Electrical Engineering]

Series solutions of differential equations, boundary value problems and orthogonal functions, and partial differential equations with applications from mathematical physics.

MA 321 Modern Algebra (3-0) 3

[MA 221-222]

A study of the basic structures of contemporary abstract algebra: groups, rings, modules, categories and functors. Fields and Galois theory.

MA 322 **Topics in Algebra** (3-0) 3

The consideration of timely topics in algebra.

MA 334 **Projective Geometry** (3-0) 3

[MA 221-222]

Foundations of geometry. Homogeneous coordinates. Projective spaces. Conics. Linear transformations. Quadric surfaces.

MA 355 or 356 **Digital Computer Programming** (2-2) 2

[Permission of instructor]

The programming and operation of the Institute's IBM 1620 digital computer and discussion of larger systems. Selected practice problems related to the specialties of the class are written by the students and tested to completion in the laboratory sessions.

MA 371-372 **Introduction to Numerical Analysis** (3-0) (3-0) 6

[MA 206]

Finite difference calculus. Approximations by polynomials, exponentials and band-limited functions. Solutions of nonlinear algebraic equations and ordinary differential equations.

MA 383 or 384 **Statistical Methods** (3-0) 3

[MA 108]

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 395-396 **Mathematics Seminar** (1-0) (1-0) 2

Reading, reports, and problem solving, pointing toward logical integration of the student's undergraduate work.

MA 401 or 402 **Foundations of Mathematics** (3-0) 3

[MA 205]

The axiomatic method, set theory, transfinite arithmetic, the real number system, and philosophies of mathematics.

MA 403 or 404 **Elementary Number Theory** (3-0) 3

[MA 205]

Properties of integers, including Euclidean algorithm, divisibility, diophantine equations, prime numbers, congruences, residues, and introductory number theory.

MA 405 or 406 Mathematical Statistics **(3-0) 3**
[MA 205]

Measurements of dispersion, theoretical frequency distributions, tests of goodness of fit and independence, partial and multiple correlations; permutations, combinations, and probability; game theory.

MA 411* Complex Variables I **(3-0) 3**
[MA 308]

Complex numbers, point sets, and elementary functions; an introduction to analytic functions; classification of singularities; line integrals; Cauchy integral formula; power series; and residues and poles.

MA 412* Complex Variables II **(3-0) 3**
[MA 411]

Conformal mapping, Schwarz-Christoffel transformation, applications, and further topics in Theory of Functions.

MA 431* Point Set Topology **(3-0) 3**
[MA 308]

Topological spaces. Continuity. Compactness and connectedness. Product and quotient spaces. Metric spaces. The fundamental group. Topological groups.

MA 432* Algebraic Topology **(3-0) 3**
[MA 431]

Homology and cohomology groups of topological spaces. Invariance. The exact homology and cohomology sequences. Applications to special cases.

MA 433* or 434* Matrix Algebra **(3-0) 3**
[MA 205]

Algebra of vectors, matrices, and determinants; linear transformations; linear vector spaces; characteristic roots and reduction to diagonal form; quadratic forms; and applications to physics.

MA 459-460* Digital Computer Programming and Numerical Analysis **(2-3) (2-3) 6**

Basic and advanced programming techniques in the use of high-speed digital computers for the solution of scientific and engineering problems. The preparation and running of sample

problems on the Institute's IBM 1620 computer and at least one other larger computer. Numerical analysis techniques include simultaneous equations, least squares data fit, interpolation, numerical solution of differential equations, and other matters.

MA 484* **Probabilities** **(3-0) 3**
[MA 302]

Elements of combinatorial analysis, introduction to probabilities, random variables and expectation, law of large numbers, central limit theorem, and elements of mathematical statistics.

MA 495-496 **Mathematics Seminar** **(1-0) (1-0) 2**

Reading, reports, and problem solving, pointing toward logical integration of the student's undergraduate work.

MA 505-506 **Mathematical Methods of Physics** **(3-0) (3-0) 6**

Elements of complex variables; Fourier and other transforms; ordinary differential equations and their classification, and Frobenius and other methods of solution; partial differential equations and their classification; boundary value problems, Sturm-Liouville theory and eigenvalues; vector spaces; Green's functions and integral equations of the first and second kind; and introduction to group theory.

MA 515 or 516 **Methods of Applied Mathematics** **(3-0) 3**

The calculus of variations, integral equations, and applications.

MA 525 or 526 **Modern Algebra** **(3-0) 3**

Topics in modern algebra, including number theory, equivalence relations, fields, integral domains, ideals, groups, Boolean algebras, sets, and matrices.

MA 533 or 534 **Matrix Theory** **(3-0) 3**
[MA 433]

The calculus of matrices, including the study of matric polynomials, series of matrices, matric functions, and differentiation and integration of matrices; association of matrices with linear differential equations; and applications of matric methods to engineering.

MA 537-538 **Group Theory** **(3-0) (3-0) 6**

Elements of set theory; mappings, isomorphisms, and cardinality; semi-groups and groups; the theory of finite groups;

general representation theory; and applications of group theory to quantum mechanics.

MA 541 or 542 — Fourier Series and Boundary Value Problems — (3-0) 3

[MA 206]

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics, and boundary value problems.

MA 543 or 544 — Partial Differential Equations I — (3-0) 3

[MA 302]

Ordinary differential equations in more than two variables, geometrical interpretations, partial differential equations of the first and second order, and boundary value problems.

MA 545 or 546 — Partial Differential Equations II — (3-0) 3

[MA 543]

Partial differential equations of the second order, boundary value problems, and a detailed study of Laplace's, equation, the wave equation, and the diffusion equation.

MA 553 or 554 — Tensor Analysis — (3-0) 3

[MA 433 or 533]

The tensor concept; covariant and contravariant tensors; the metric tensor, associated tensors, and covariant differentiation; Euclidean and Riemannian manifolds; and applications to geometry and analytical mechanics.

MA 557-558 — Computers — (3-2) (3-2) 8

[MA 302]

The principles of analog and digital computers as a basis for assessing and planning their use in scientific work. Logic design, instrumentation, programming, and numerical analysis. A survey of well-known commerical analog and digital computers. Experience with the computers at the Institute and also a visit to a local computing center having different equipment, during which a course-programmed problem may be run.

MA 563 or 564 — Projective Geometry — (3-0) 3

[MA 205]

An introduction to various non-Euclidean geometrics. Point

sets on a line, line pencils, homogeneous coordinates, and the theory of conics and quadrics. Multidimensional geometry, Plucker coordinates, and correlations and collineations in space.

MA 573 or 574 **Functions of a Complex Variable** **(3-0) 3**
[MA 302]

Complex numbers, point sets, and elementary functions; an introduction to regular analytic functions; classification of singularities; and conformal mapping and applications.

MA 575 or 576 **Operational Mathematics** **(3-0) 3**
[MA 302]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentiation, and integration. Elementary applications in the analysis of vibrations, deflections, and electric circuits; problems in partial differential equations; and Fourier transforms.

MA 585-586 **Random Processes and Noise Theory** **(3-0) (3-0) 6**
[MA 302]

Principles of random noise theory and optimum filtering. Development of the concepts of correlation function and power spectra for the detection of signals in noise. Illustration of the theory in some applications of circuits and computers with emphasis on the formulation of the noise problem, its mathematical solution, and the interpretation of the results for proper design of systems.

MA 591 or 592 **Graduate Thesis** **Credits to be arranged**

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

MA 595-596 **Mathematics Seminar** **Credit to be arranged**

Introduction to mathematical research through reading, reporting, and critical evaluation of assigned topics.

MECHANICAL ENGINEERING

ME 101 — Engineering Graphics — (1-2) 1

Communication by graphic representation—orthographic and pictorial. Charts and graphs. Freehand and instrumental multiview drawing, dimensioning, engineering geometry, pictorial sketching, and projection.

ME 102 — Engineering Graphics — (1-2) 1

[ME 101]

The use of graphics in the solution of problems. Visualization by descriptive geometry, and its exercise in vector geometry and intersections. Graphical calculus, nomography, and empirical equations.

ME 201 — Mechanical Engineering Laboratory I — (2-2) 2

Kinematic analysis of mechanisms. Velocity, displacement and acceleration diagrams; gear trains; cams; motion diagrams; limits, fits and tolerances; layouts, details and assemblies; flow diagrams and applications.

ME 203 — Introduction to Mechanical Engineering — (1-0) 1

The history, accomplishments, and prospects of Mechanical Engineering. The design process including creativity, problem formulation, decision making and specifications. Ethics, responsibilities, and professional development of Engineering.

ME 211 — Engineering Mechanics I — (3-0) 3

[MA 108, PH 105]

[For students of Mechanical and Nuclear Engineering only]

A development of fundamental ideas of mechanics such as vectors, forces, and moments, using the methods of vector algebra. A detailed treatment of the free body diagram concept and its application to resultants of force systems, laws of static equilibrium, friction forces, first and second moments, and problems involving various structures and machine parts. First and second moments of scalar quantities are also considered.

ME 212 — Mechanics and Properties of Matter — (4-0) 4

[MA 206 taken concurrently]

[Limited to students of Electrical Engineering]

This course covers selected topics in Mechanics which are

of fundamental importance to students majoring in Electrical Engineering. These include kinematics, Newton's laws, work, energy, free and forced harmonic oscillations, rotational motion of rigid bodies, stress and strain relationships, moduli of elasticity and wave motion. The treatment is at the intermediate level.

ME 214 — Engineering Mechanics II — (3-0) 3

[ME 211]

[For students of Mechanical and Nuclear Engineering only]

A continuation of ME 211. The basic laws of kinematics of particles and rigid bodies which involve linear, angular, relative, and absolute motion; Newton's laws and their application to the kinetics of rigid bodies in translation, rotation, and plane motion; and the principles of work, kinetic energy, impulse, and momentum.

ME 215 — Analytic Mechanics I — (3-0) 3

[MA 108, PH 103]

[For students of Textile, Chemical and Paper Engineering]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 — Analytic Mechanics II — (3-0) 3

[ME 215]

[For students of Textile, Chemical and Paper Engineering]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 261 or 262 — Machine Tool Laboratory — (1-2) 1

The use of basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, gears, and gearing.

ME 263 or 264 — Metals Processes — (1-2) 1

A study of the modern methods of manufacture along with some of the most recent developments such as high velocity forming—explosive welding, ultrasonic and chemical milling,

electrolytic grinding, etc. This is done through lectures, movies and guest speakers. Also, a study of engineering metrology by laboratory experiments and lectures. Also some practical experience in basic machine operation.

ME 311 Mechanics of Materials I (3-0) 3
[ME 211 or 215]

A basic course in strength of materials, including tension, compression, shear, and combined stresses; the Mohr circles for stress and strain; shearing force and bending moment diagrams; stresses and deflections of beams in bending; statically indeterminate problems; and torsion of circular sections and stresses in columns.

ME 313 Mechanics of Solids I (3-0) 3
[For students majoring in Plastics Technology]

Statics of rigid bodies, energy principles, kinematics and dynamics of particles and rigid bodies, and introduction to vibrations.

ME 314 Mechanical Engineering Laboratory II (0-3) 1
[ME 341 or ME 345]

An introduction to standard test methods for determining physical properties of engineering materials and techniques for altering these properties. The student is introduced to supplementary methods of materials analysis which include metallography, x-ray diffraction, electron microscopy, and diffraction spectrography.

ME 315 Applied Mechanics (3-0) 3
[MA 108, PH 103]
[For students of Industrial Management and Paper Engineering]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 318 Engine Dynamics (3-0) 3
[ME 214]

Inertia and stress tensors. Dynamics of a particle, principle of d'Alembert. Projectile motion with air resistance. Theory of impact, the impact of free body, restrained impact. Forced motion of a bar. Theory of vibration: Harmonic-, twisting-, damped-, and forced vibrations. Sound wave. Lagrange's equations, Hamilton's equations and applications. Movement of gyroscope.

ME 341 **Thermodynamics** **(3-0) 3**

[MA 205, PH 104 or PH 106]

[For students of Mechanical and Nuclear Engineering only]

A detailed consideration of the first and second law with analysis of open and closed systems in steady and unsteady flow. The pure substance, the perfect gas. Entropy and its relationship to probability. Absolute temperature. Availability. Gibbs-Dalton mixtures.

ME 342 **Thermodynamics** **(3-0) 3**

[ME 341]

[For students of Mechanical and Nuclear Engineering only]

The application of the laws of thermodynamics to energy conversion cycles, chemical reactions and fluid dynamic processes. Thermodynamics equilibrium. Real gases, generalized thermodynamic relations.

ME 344 **Heat and Power** **(3-0) 3**

[MA 108, PH 104]

[Not open to students in Electrical, Mechanical, or Textile Engineering]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 345 **Thermodynamics** **(3-0) 3**

[MA 205, PH 206]

[Closed to students of Mechanical Engineering]

A study of the first and second law with applications to open and closed systems in steady and unsteady flow. The pure substance, the perfect gas. Availability.

ME 346 **Thermodynamics** **(3-0) 3**

[ME 345]

[Closed to students of Mechanical Engineering]

Properties of mixtures of gases and vapors. Application to vapor power and refrigeration cycles; air standard cycles; humidity problems; combustion problems.

ME 372 **Strength of Materials** **(3-0) 3**

[ME 315]

[For students of Industrial Management and Paper Engineering]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses,

analysis of principal stresses, Mohr's circle of stress, and design of members and columns.

ME 374 Plastics Mold Design and Construction (1-2) 1

[ME 261 or 262]

A study of the basic types of plastic molding machines along with the basic principles of mold design and construction. The design and construction of simple molds is carried out by actual laboratory work for use on the plastic machines in the Department of Plastic Technology.

ME 375 or 376 Materials Science (3-0) 3

[PH 104 or PH 106]

The dependence of the properties of materials in general on atomic and crystalline structure. X-ray diffraction; equilibrium and rate processes; interatomic attractive forces; diffusion; theory of dislocations; mechanical, electrical, electronic, magnetic, and thermal properties. Standard physical tests and assigned projects are performed in the laboratory.

ME 377 Elements of Materials Science (2-0) 2

[Not open to students fo Electrical, or Mechanical, Engineering]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, strain hardening and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 378 Mechanics of Solids II (3-0) 3

[For students majoring in Plastics Technology]

Static and dynamic behavior of deformable systems. Stress and strain, torsion, compound stresses, analysis of plane stress and strain, failure theories, statically indeterminate members, stability and buckling, and stresses and deformations in bodies under dynamic loading.

ME 382 Fluid Mechanics I (3-0) 3

[MA 205, PH 106]

[For students of Mechanical and Nuclear Engineering only]

Introduction. Fluid properties. Fluid statics, fluid-flow concepts and basic laws, viscosity or internal friction. Dimensional analysis. Ideal fluid flow. Resistance of immersed bodies, dynamics lift. Flow in a curved path. Flow in open channels, closed conduit flow. Turbomachinery, fluid measurement.

ME 384 **Fluid Mechanics** **(3-0) 3**

[MA 205, PH 205]

[Closed to students of Mechanical Engineering]

Includes study of fluid statics: pressure and fluid forces on submerged surfaces; buoyant force. Fundamentals and phenomena of the flow of "ideal" fluids: equations of continuity, Euler and Bernoulli, and momentum. Potential flow. Dimensional analysis: π-theorem. Flow of "real" fluids: viscous effects, Reynolds N^0, boundary layer, losses, drag, pipe networks, open channel flow. Fluid measurements, turbomachinery.

ME 394 **Automatic Control Systems I** **(3-0) 3**

[EE 212, MA 206]

Concept of open and feedback control systems. Use of block diagram and transfer functions for system representation. Analytical techniques for evaluation of system performance; transient and steady state response, stability and compensation.

ME 415 **Mechanical Engineering Laboratory III** **(0-3) 1**

[ME 314]

Experimental work in the areas of mechanical engineering which includes thermodynamics heat transfer and fluid mechanics. The operation and analysis of a steam turbine, gas turbine, and air compressures, wind tunnels, flow apparatus, boilers and related equipment.

ME 416 **Senior Project** **(0-3) 1**

[ME 415]

An individual project selected by the student in consultation with the staff. The project must include phases of design, construction, and analysis. Both a formal written report and an oral presentation are required.

ME 421 **Machine Design** **(2-3) 3**

[ME 214, ME 311 or ME 215, ME 216]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes, bearings, gears, and cams. Theories of failure and methods of establishing working stress levels are considered. The laboratory work consists of comprehensive projects that illustrate the close relationship between analysis and synthesis as they are applied to various machine design problems.

ME 422 **Mechanical Engineering Design** **(3-0) 3**
[ME 318, ME 342, ME 443]

This course attempts to integrate the subjects of Mechanics (Rigid Body and Fluid), Thermodynamics, Heat Transfer, and Controls as they are required for the design of representative mechanical systems. The processes of analysis, decision making, and synthesis are illustrated and applied to suitable design projects.

ME 442 **Select Problems in Thermal Engineering** **(2-0) 2**
[ME 342, ME 482]

The application of fluid dynamics, thermodynamics and heat transfer to engineering systems. Selected design problems from the areas of reciprocating and rotating machines, propulsion power plants, combustion and nuclear power plants, direct energy conversion.

ME 443 **Heat Transfer** **(3-0) 3**
[MA 206, ME 341 and 382]
[For students of Mechanical and Nuclear Engineering]

Modes of heat flow; combined heat transfer mechanisms: analogous electrical network; conduction (steady state and transient): exact and approximate methods of analysis (flux plot, Schmidt plot, finite differences); radiation heat transfer; dimensional analysis, fluid flow, and boundary layer theory. Reynolds analogy; Nusselt, Prandtl, Biot, Fourier, Graetz, and Grashof numbers; free convection; forced convections; heat transfer to boiling liquids and condensing vapors; and finned surfaces and heat exchangers.

ME 445 **Heat Transfer** **(3-0) 3**
[MA 206, ME 345, ME 384]
[Closed to students of Mechanical Engineering]

General heat transfer fundamentals and methods of analysis for problems involving conduction through solids during both steady state and transient conditions, heat exchange by thermal radiation, free convection, forced convection, finned surfaces, tube bundles and heat exchangers.

ME 455 or 456 **Information Processing Systems** **(2-2) 3**
[MA 359 or permission of instructor]

The use of electronic computing systems for the solution of engineering problems, with stress on symbolic programming methods. Student use of the IBM 1620 installation at the Institute is an integral part of the course.

ME 471 or 472 Experimental Stress Analysis (2-2) 3
[MA 206, ME 311]

Elementary elasticity relationships; photoelasticity theory and applications; birefringent coatings; Moiré methods in strain analysis; electric resistance strain gage; strain rosette analysis; brittle coatings; analogies; mechanical and optical strain gages.

ME 474 Mechanics of Materials II (3-0) 3
[MA 311, ME 311]

Equations of elasticity: Mohr's circle: Shear Center: Unsymmetrical bending: Curved beams: Beams on elastic foundations: Torsional resistance of non-circular sections: Thick walled cylinders: Contact stresses: Energy methods and analogies.

ME 476 Physical Metallurgy (3-0) 3
[MA 206, ME 106; ME 375 or 376]

A study of metals and alloys. Phase diagrams and transformations, the carbon-iron system, all metallic properties and their structure sensitivity. Modern theory and methods of producing metals for specific requirements. Electron and nuclear damage.

ME 482 Fluid Mechanics II (3-0) 3
[ME 382]

Theorems and basic flow definitions. Stokes' theorem and stream function for three-dimensional flow. Green's theorem for kinetic energy equation. Cauchy-Riemann equations. Theory of conformal mapping and applications. Jonkowski airfoil, Wing theory, drag, Von Karman integral relation. Blasius theorem for flow around cylinder and airfoil. Boundary layer theorem, Pohlhausen analysis of the boundary layer, the boundary layer for turbulent flow. Schwarz-Christoffel theorem for free streamlines. Viscous flow around a sphere at very low velocity. Fluid vibrations. Theory of hydraulic turbines.

ME 491 Measurement Engineering (3-0) 3
[EE 212, MA 206]

Techniques and instrumentation for the measurement of engineering parameters; temperature, force, stress, strain, motion, pressure, flow, time, frequency. Energy Transducers. Mode of operation, accuracy and response characteristics. Statistical methods for evaluation of reliability of measurements.

ME 493 or 494 Industrial Instrumentation (2-0) 2

[MA 108, PH 104]

[Not open to students majoring in Electrical, Mechanical, or Textile Engineering]

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric, and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

ME 495 Auto Control Systems II (3-2) 4

[ME 394]

The design, analysis and application of mechanical, electrical, pneumatic, and hydraulic control systems; regulators and servomechanisms; multiple loop systems, system improvement, treatment of nonlinear systems.

ME 528 Kinematic Mechanism Synthesis (3-0) 3

[ME 214]

Mechanism concepts, symbolic notations, coupler curves, and the Gruebler criterion. Planar linkage synthesis by geometric methods, synthesis of function generators and dwell linkages, and the Euler-Savory equation. Analytic methods of synthesis, Freudenstein's method, kinematics of spatial mechanisms, matrix representation of rotation, and general matrix methods of analysis.

ME 541 Statistical Thermodynamics (3-0) 3

[ME 341]

Statistical mechanics for systems of independent particles. Quantum mechanics for particle motion. Thermodynamic properties of monatomic gases and solids, polyatomic gases. Irreversible processes, Onsager relations.

ME 542 Direct Energy Conversion (3-0) 3

[ME 541]

Irreversible thermodynamics. Electronic transport, surface phenomena. Thermoelectric and thermionic generators.

ME 555 or 556 Advanced Computer Problems (3-0) 3

[ME 455 or 456; permission of instructor]

An opportunity for students familiar with computers to develop advanced problem application of particular interest to them.

ME 576 Nondestructive Evaluation Techniques for Materials and Processes (3-0) 3

[ME 318]

The nondestructive evaluation of materials and processes by penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitations of each. Particular emphasis is placed upon the analysis and correlations of the interactions of these energy forms with material properties and processes: flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical, and metallurgical properties.

ME 581 Orbital and Ballistic Mechanics (3-0) 3

[ME 382]

Introduction of the mechanics of a free point mass, the attractive force, classical two-body problem. Equation of the trajectory of a point moving under the effect of Earth's attraction. Trajectories to the initial motion conditions, magnitude of the flight velocity, flight altitude, angular flight range, direction of the flight velocity, flight time. Deviation in the angular flight range, and in the flight time caused by initial deviations. The transfer velocity, a double-thrust departure, and the continuous trajectory.

ME 582 Aero- and Astrodynamics (3-0) 3

[ME 443, ME 581]

Interpretation of the coefficient of viscosity and thermal conductivity. Irrotational flow, vortex flow. The energy relations. One-dimensional compressible flow. Normal-, plane oblique-, and conical oblique shock waves. Wings in compressible flow. Celestial dynamics: The two-, three-, and n-body problems. The Lunar trajectories. The Lifttime of Artificial Earth Satellites, perturbations of artificial satellites. The entry dynamics and solutions. Variable flight and solutions of planetary entry. Aerodynamic heating and ablation-shield analysis.

NUCLEAR ENGINEERING

NU 201-202 Introduction to Nuclear Engineering (3-0) (3-0) 6

A general review of atomic and nuclear structure, the properties of nuclear radiations, and radiation measurement. Nuclear forces and nuclear structure. Neutrons and fission. Utilization of nuclear energy. Nuclear reactors. Fuels and fuel reprocessing. Health Physics and radiation protection. Accelerators. Fusion reactions and the long-term energy picture.

NU 301-302 Radiological Health (3-0) (3-0) 6

Nature, sources and effects of radiation. Mechanisms. Absorption and attenuation. Effect on living matter. Somatic and genetic effects. Maximum permissible doses and concentrations. Dosimetry. Shielding. Ventilation. Contamination. Waste disposal. Regulations and compliance.

NU 305-306 Nuclear Instrumentation (2-4) (2-4) 6

The first semester lectures cover the fundamentals of circuit theory as applied to pulse circuits, and the laboratory covers the construction, testing, and evaluation of component circuits and instruments. The second semester lectures are devoted to the design and operating characteristics of detectors and their use with electrometers, ratemeters, scalers, and pulse height analyzers. The laboratory work of the second semester is devoted mainly to the characteristics of detectors and associated measuring circuits.

NU 403-404 Reactor Instrumentation (2-4) (2-4) 6

Elements of servomechanisms; automatic control systems; electrical and electronic theory utilized in the measurement of reactor parameters such as reactivity, danger coefficients, and temperature coefficients; detection of neutron flux with fission, BF_3, and ionization chambers; analysis and design of power-measuring and period-measuring instruments; and calibration of control rods and general reactor control devices.

NU 405-406 Nuclear Reactor Engineering (3-0) (3-0) 6

Neutrons, cross-sections and fission. Steady state and the criticality condition. Reflected, homogeneous and heterogeneous reactors. Fast reactors. Reactor control. Kinetics and reactiv-

ity effects. Control systems and instruments. Coolants and moderators. Fuels. Reactor Operation.

NU 410 Nuclear Safety and Site Analysis (3-0) 3

Normal and abnormal conditions. Transient behavior. Accident types. Release of fission products. Containment and confinement. Spray, filtration and emergency exhaust systems. Design of ventilation systems. Elevated stacks and Sutton's equations. Part 50 and Part 100 regulations, exclusion radius and other site parameters.

NU 493-494 Nuclear Laboratory (0-6) (0-6) 4

The first semester is devoted to the use and interpretation of gamma spectra, and a series of experiments using a neutron source. The second semester is devoted to neutron spectroscopy and more advanced experiments using the nuclear reactor and accelerator. Discussion periods as necessary.

PAPER ENGINEERING

PA 301 Engineering Analysis of Pulp Systems (3-0) 3
[CHE 204]

Lectures and problems concerning the engineering, design, and technology of pulp manufacture by all commercial processes. Discussion of bleaching chemistry, fundamentals of cellulosic chemistry involved in processes.

PA 302 Engineering Analysis of Paper Systems (3-0) 3
[PA 301]

Discussion and study of engineering, design and economics of commercial methods of producing paper. Stock preparation, changes in physical and chemical properties of pulps, filling and loading of fibers, sizing, coloring, additives. Material and energy relationships of various processes.

PA 307 Analysis and Design of Testing (3-0) 3

Analysis of the fundamentals of mechanical testing of paper and other materials. Discussion of engineering mechanics of various testing procedures; statistical analysis of testing; discussion of results of tests as reflected in structure of material tested.

PA 308 Pulp and Paper Laboratory (0-6) 2
[PA 301, taken concurrently with PA 302]

Laboratory projects designed to illustrate the processing of pulp and paper; relationships between processing and properties of paper; written reports. Evaluation of TAPPI methods; chemical analysis of pulps and papers; physical testing and correlation of tést results with processing operations.

PA 403 Engineering Analysis of Converting Processes (3-0) 3
[PA 302, PA 308]

Lectures and problems concerning the engineering, design, technology and economics of paper and paperboard converting processes. Rheology of coating materials and engineering properties of materials. Mechanical, coating, impregnating and printing processes.

PA 405 **Converting Laboratory** **(0-6) 2**
[Taken concurrently with PA 403]

Common techniques employed in the paper and paperboard industry and use of TAPPI Methods. Emphasis is placed on the colloidal and rheological properties of materials used. Detailed written and oral reports are required.

PA 410 **Engineering Analysis of Paper Processing** **(3-0) 3**
[PA 403]

Individual subjects involving engineering, design and chemical problems of certain aspects of paper manufacturing and converting. Emphasis on structure of basic cellulosic fibers as it is affected by mechanical and chemical operations. Written and oral reports. Plant visits in specialized subjects.

PA 501-502 **Graduate Thesis** **Credits to be arranged**

Every graduate student is required to write a thesis on original research work done under the supervision of a senior staff member, and this thesis must be approved by an examining committee appointed by the Department Head.

PA 503-504 **Advanced Converting Processes** **(3-0) (3-0) 6**
[PA 403, PA 405]

Specific converting processes; coating operations, both water-based and solvent-based; latest techniques used by the converting industry, involving mechanical and chemical operations. Engineering analysis of processes. Oral and written reports are required. Plant visits of specific converting problems.

PA 505 **The Physics of Paper** **(3-0) 3**

Structures of fibers from a fundamental viewpoint and their effect on strength and other properties of sheets made from these fibers. Comparison of cellulosic fibers and synthetic fibers. Engineering properties of fiber materials.

PA 506 **New Techniques in the Paper Industry** **(2-0) 2**

A seminar to discuss new developments in engineering, design and application of physical and chemical principles in the manufacture of paper and paper products. Economic studies of new processes. Plant visits; oral and written reports.

PA 508 Advanced Paper Systems Analysis (2-0) 2

Chemistry and engineering principles applied to nonfibrous components in papermaking.

PA 509-510 Paper Engineering Seminar (1-0) (1-0) 2

PHYSICS

PH 101-102 **General Physics** **(3-2) (3-2) 8**

[For students majoring in Business Administration]

Mechanics, heat, wave motion, sound, light, electricity and magnetism, and modern physics. Lectures, experimental demonstrations, and laboratory.

PH 103 **Physics** **(4-1) 4**

[MA 107 taken concurrently]

The principles of mechanics, including physical measurement, composition and resolution of vectors, motion in one dimension and in a plane, particle dynamics, work and energy, conservation of energy, conservation of linear and angular momentum, rotational kinematics and dynamics, statics of rigid bodies, mechanical oscillations, and gravitation.

PH 104 **Physics** **(4-2) 4**

[PH 103 or equivalent]

The principles of electricity and magnetism. Charge and matter, electric fields, Gauss's law, electric potential, capacitance and inductance, and transients in circuits containing inductance, capacitance, and resistance. Magnetic fields, Ampere's law, Faraday's law, and electromagnetic oscillation.

PH 105-106 **Introduction to Physics** **(4-1) (4-2) 8**

[MA 107-108 taken concurrently]

The basic principles of mechanics, heat, wave motion, sound, and optics; the dual aspects of radiation and matter, the variation of mass with velocity, and Bohr's theory of the atom and some of its consequences.

PH 205 **Physics** **(4-2) 4**

[MA 205 taken concurrently; PH 104]

Temperature; heat and the first law of thermodynamics; kinetic theory of gases, including specific heats; and the second law of thermodynamics. Mechanical oscillators; traveling elastic waves; standing waves; acoustical and optical wave phenomena, such as beats, the Doppler effect, reflection, refraction, interference, and diffraction; polarization; and spectra.

PH 206 **Physics** **(4-2) 4**

[PH 205]

Review of classical ideas; the restricted theory of relativity; particle aspects of electromagnetic radiation; wave aspects of material particles; the hydrogen atom; many-electron atoms; x-ray spectra; nuclear accelerators; nuclear structure and nuclear reactions; and molecular and solid-state physics.

PH 208 **Modern Physics** **(3-2) 4**

[PH 205]

[For students majoring in Nuclear Engineering]

Charged particle motion in electromagnetic fields, black body radiation, the photoelectric effect, the special theory of relativity, the Bohr atom, quantum mechanics, X-ray scattering and absorption, Compton scattering, and the kinetic theory of gases.

PH 209 **Problems in Physics** **(1-0) 1**

[PH 205 taken concurrently]

Practice in the careful analysis of physical situations and in their formulation, by way of the solution of the specific problem posed. Problems of a level comparable with that of the accompanying elementary course are solved, and may be in any portion of the field previously or concurrently studied.

PH 210 **Practical Astronomy** **(3-0) 3**

[MA 205]

Coordinate systems, marine navigation, space navigation, the gravitational potential, Keplerian orbits, and the rendezvous problem in space. The material is developed mainly through the solution of problems.

PH 242 **Modern Physics** **(4-2) 4**

[PH 205]

[For students majoring in Physics or Nuclear Science]

The special theory of relativity, thermal radiation, black body radiation, Planck's theory of black body radiation, discovery of the electron, classical and quantum theories of the photoelectric effect, the Compton effect, Thompson's description of the atom, the Rutherford experiment, atomic spectra, Bohr's theory of the one-electron atom, the Wilson-Sommerfeld quantization rule, Sommerfeld's relativistic theory, DeBroglie's theory, the uncertainty principle, formulation of Schrodinger's equation, and the energy quantization of a free particle.

PH 244 **Optical Instruments** **(1-2) 2**

[PH 205 taken concurrently]

The basic laws of optics and their application to various optical instruments used in industry, such as the microscope, telescope, refractometer, and colorimeter. Considerable emphasis in the laboratory work is placed on the general use of the microscope.

PH 257 **Electric Circuits** **(2-0) 2**

[MA 205 taken concurrently; PH 108]

A short course designed to cover the fundamentals of circuit theory. Basic direct-current circuit theorems; simple transient problems in a.c. circuits; steady-state solutions for the simple series circuit: impedance and resonance; the parallel resonant circuit: admittance. Some mechanical analogs are derived. The elementary theory of differential equations and the complex variable are developed where needed. Outside work emphasizes the application of the theory to the solution of problems.

PH 258 **Electrical Measurements** **(1-3) 2**

[MA 205, PH 205]

Precision of measurements, zero-frequency and low-frequency measurements by both deflection and null methods, amplifiers and tube electrometers, oscilloscopes, Geiger and proportional counters, magnetic measurements, and electrical measurements in mechanics, heat, acoustics, optics, and nuclear science.

PH 293 **Laboratory Practice** **(1-2) 1**

[Permission of Instructor]

Practice in laboratory techniques, such as glass blowing, simple machine work, and dealing with vacuum systems. The proper keeping of notebooks, the analysis and evaluation of data, and the writing of reports.

PH 311-312 **Intermediate Mechanics** **(3-0) (3-0) 6**

[MA 206]

Vector analysis, statics of systems of particles, rectilinear motion of a single particle, the linear oscillator, motion in two and three dimensions, Stokes' theorem, conservative forces, central field motion, motion of systems of particles, generalized coordinates and momenta, Lagrange's equations, motion of rigid bodies, the spinning top, the coupled oscillator, normal coordinates, and the vibrating string.

PH 321 or 322 Intermeidate Thermodynamics **(3-0) 3**

[MA 206]

Analysis of temperature, thermodynamic systems, ideal gases, the first and second laws of thermodynamics, reversible processes, the Carnot cycle, entropy and its philosophical significance, properties of pure substances, and various applications.

PH 323 or 324 Introduction to Statistical Mechanics **(3-0) 3**

[PH 312 taken concurrently; PH 321]

Introduction to probality theory, classical Maxwell-Boltzmann statistics, classical statistical mechanics, statistical mechanical interpretation of thermodynamics, and applications to the kinetic theory of gases.

PH 343-344 Atomic and Nuclear Physics **(3-0) (3-0) 6**

[MA 206, PH 206; PH 311-312 taken concurrently]

Atoms as components of matter; particle beams in electric and magnetic fields; and magnetic, optical, and electrical properties of atoms. X-rays, photons and X-ray spectra, optical spectra, the special theory of relativity, the Schrodinger equation, and electron spin and multiplet spectra. Radioactivity, Rutherford scattering, nuclear radii, wave mechanics, cross sections, and nuclear reactions.

PH 345-346 Atomic and Nuclear Physics **(3-0) (3-0) 6**

[MA 206, PH 206; PH 311-312 taken concurrently]

The special theory of relativity; relativistic mechanics; scalar invariants, 4-vectors, and tensors; the Lorentz transformation and particle collisions; an introduction to quantum mechanics; and the one-electron atom. The Pauli exclusion principle; atomic shell structure, the multielectron atom, and atomic spectroscopy; the Zeeman effect, the Stark effect, and the Paschen-Back effect; basic properties of nuclei; charge, mass, and magnetic moments; radioactivity; and excited nuclear state and nuclear reactions.

PH 347 or 348 Physical Optics **(3-0) 3**

[PH 353 or 354]

The theoretical and experimental aspects of the phenomena of interference, diffraction, and polarization of electromagnetic waves, especially light and microwaves.

PH 353-354 **Electromagnetic Theory** **(3-0) (3-0) 6**

[MA 301-302 taken concurrently; PH 205]

The theory of electromagnetic fields using vector analysis and Maxwell's equations. Static electric and magnetic fields in dielectrics, conductors, and ferromagnetic materials; the scalar and vector potentials and time-varying fields; and the special theory of relativity. Plane waves in dielectrics and conductors, the Poynting vector, Fresnel's equations, and waveguides; radiation from antennas and accelerated charges; polarization, interference, and diffraction; and receivers.

PH 355-356 **Electromagnetic Theory** **(3-0) (3-0) 6**

[MA 301-302 taken concurrently; PH 205]

Forces and fields; Maxwell's equations; electrostatics: expansion in multipole moments, Poisson's and Laplace's equations, and images; magnetic fields; and scalar and vector potentials. Electromagnetic induction, energy density and Poynting vector, and the equation of continuity. The electromagnetics of material media: polarization, dielectrics, and magnetization. Physical optics: reflection and refraction of electromagnetic waves, Fermat's principle, Huygens' principle, and Fraunhofer and Fresnel diffraction. The Special Theory of Relativity, space-time and field transformations, relativistic dynamics, the electromagnetic field tensor, and the covariant formulation of physical laws. Radiation from accelerated charges. The scattering of electromagnetic waves.

PH 363 **Introductory Nuclear Physics** **(3-0) 3**

[MA 206, PH 208]

[For students majoring in Nuclear Engineering]

Natural radioactivity; the Bateman equations; isotopic abundance; induced activity; the energetics of nuclear reactions; and alpha, beta, and gamma emission.

PH 366 **Intermediate Nuclear Physics** **(3-0) 3**

[PH 363]

[For students majoring in Nuclear Engineering]

The compound nucleus and resonance theory, cross sections, Rutherford scattering, center of mass coordinates, neutron physics, nuclear radii, nuclear stability and forces between nucleons, and nuclear models.

PH 393-394 **Experimental Physics** **(1-3) (1-3) 2**

[Permission of instructor]

Experiments in electromagnetics, optics, electronics, atomic and nuclear physics, mechanics, and other interesting fields.

PH 405 Introduction to Theoretical Physics (3-0) 3

[PH 312, PH 354]

A study of mechanics, field theory, variational methods, and other aspects of theoretical physics.

PH 411-412* Quantum Theory (3-0) (3-0) 6

[MA 433 and MA 484 taken concurrently; PH 311 or 312]

The beginnings of the quantum theory. The Bohr-Sommerfeld theory; wave-particle dualities and the uncertainty principle; the DeBroglie theory; basic principles of wave mechanics; Schrodinger's equation and applications; operators and observables; commuting properties of operators and their relationships to the uncertainty principle; mathematical theory of eigenfunctions, Fourier series, and the Fourier integral; matrix mechanics; perturbation theory by wave and matrix mechanics; and applications.

PH 424 Introduction to Statistical Physics (3-0) 3

Kinetic theory, statistical mechanics, and other statistical studies.

PH 425 or 426 Meteorology (3-0) 3

[MA 205]

Introduction to meteorological science; the atmosphere, clouds and precipitation, heat and temperature changes, radiation balance and global circulation, equations of motion, air masses and fronts, cyclones and tropical storms, and climatology; observations and analyses; maps and forecasts.

PH 427 Introduction to Theoretical Meteorology (3-0) 3

[MA 206, PH 205]

Meteorological thermodynamics: adiabatic processes; thermodynamic diagrams; hydrostatic equilibrium; hydrostatic stability and convection. Equations of motion on a rotating earth; horizontal motion under balanced forces.

PH 431 or 432* Theory of Vibrations and Sound (3-0) 3

[MA 301, PH 312]

Free, damped, and forced oscillations; forcing by pulses; coupled oscillations; the flexible string; end conditions; perturbations; the vibration of bars, membranes, and plates; sound waves; acoustic impedance; the radiation and scattering of sound; normal modes; and reverberation. Applications are stressed.

PH 443 **Spectrographic Methods** **(2-3) 3**
[PH 206]

A course exploring the merits of spectroscopy as a tool for the investigating scientist. The theoretical prediction of line and band spectra and the theory and operation of various spectrograph designs.

PH 445 **X-Ray Diffraction** **(1-6) 3**

Theory of X-ray production; absorption; scattering by electrons and atoms; crystallographic notation; Laue equations; and determination of crystal structure. For those whose background interests involve fibers, some opportunity for investigation of these is offered in the laboratory work.

PH 448 **Electron Microscopy and Electron Diffraction** **(2-3) 3**
[PH 206 or PH 242]

Analogies with optics, electrostatic and magnetic lenses, electron trajectories, the scattering of electrons, electrons, electron diffraction and the wave properties of the electron, vacuum techniques, thin films by vacuum evaporation and electropolishing, specimen preparation, qualitative and quantitative evaluation of the electron image, and photographic techniques.

PH 449 or 450 **Infrared Radiation** **(2-3) 3**
[PH 206]

The use of infrared radiation as a means of scientific investigation. The laws and theories of black body radiation, including those of Planck, Wien, and Stefan-Boltzmann. The theory and operation of various infrared detectors and systems of collecting optics.

PH 454 **Piezoelectric Crystals** **(2-3) 3**
[PH 311, PH 353]

Phenomena in piezoelectric crystals and measurements of related quantities. Parameters of the equivalent circuit of a resonator, vibrational modes, elastic coefficients and temperature effects, the consequences of cutting plates of different orientations, and effects of surface shaping. Applications such as in transducers, frequency stabilization, ultrasonic wave generation, wave filtering, and clock control.

PH 462* **Nuclear Physics** **(3-0) 3**
[MA 302; PH 344 or 366]

Ionization of matter by charged particles, mass-energy re-

lationships, packing fraction, elementary discussion of properties of a nucleus, radioactive decay, systematics of alpha and beta decay, alpha decay theory, gamma emission, two nucleon systems, nuclear reactions and nuclear structure, and properties of neutrons.

PH 471-472* **Solid-State Physics** **(3-0) (3-0) 6**

[PH 411-412 taken concurrently]

Crystal structure and X-ray and neutron diffraction; free electron model; band theory of solids; quantum mechanical considerations; lattice energy, lattice vibrations, and infrared absorption; lattice defects; thermal properties of solids; dielectric and magnetic properties; mechanical properties; and semiconductor crystals.

PH 493-494 **Advanced Laboratory** **(1-3) (1-6) 5**

[Permission of instructor]

A laboratory couse which accompanies the senior courses in the department and which may serve as a vehicle for undergraduate experimental research in selected fields of physics.

PH 495 or 496* **Special Research Problems** **Credits to be arranged**

[Permission of Head of Department and instructor]

Special problems in theoretical and experimental physics assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

PH 497-498* **Biophysics Seminar** **(1½-0) 1**

A seminar-type course with students leading discussions on almost any topic of physical interest in biology. An attempt is made to survey this vast field, but emphasis is mainly on the physics of the sense organs, nerve conduction, and muscle contraction; the effects of radiation on living cells; molecular biology; applications of information theory to biology; and descriptions of some of the newer instrumentation for research.

PH 507 **High-Energy Physics** **(3-0) 3**

[PH 516]

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation laws of high-energy physics, strong and weak interactions, and an introduction to the theory of unitary symmetry and its consequences.

PH 511-512 **Classical Mechanics** **(3-0) (3-0) 6**
[PH 312]

Lagrange's equations, Hamilton's principle, holonomic and nonholonomic constraints, the two-body problem, matrix formulation of rigid body motion, Hamilton's equations, principle of least action, canonical transformations, Hamilton-Jacobi theory, and the theory of small oscillations.

PH 515-516 **Quantum Mechanics** **(3-0) (3-0) 6**
[MA 433, PH 411; PH 511-512 taken concurrently]

Wave packets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum, spin, and time-dependent and independent perturbation theory. Scattering theory.

PH 517-518 **Advanced Quantum Mechanics** **(3-0) (3-0) 6**
[PH 516]

The formal theory of scattering. The Klein-Gordon and Dirac equations, the Foldy-Wouthuysen transformation, elements of covariant perturbation theory based on Feynman's propagator approach, and renormalization theory. Second quantization and canonical commutation rules, the connection between spin and statistics, the TCP theorem, and selected topics in strong and weak interactions.

PH 519 or 520 **Theory of Weak Interactions** **(3-0) 3**

The four-Fermi interaction, beta decay, two-neutrino theory, violation of space and time symmetries, conservation laws and selection rules, conserved vector current, SU (3) transformation properties of the weak Lagrangian, and electron and muon neutrinos and the intermediate vector boson.

PH 521 or 522 **Statistical Mechanics** **(3-0) 3**
[PH 324]

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and Bose-Einstein, and applications to thermodynamics, solid-state physics, and nuclear physics.

PH 523 or 524 **Low-Temperature Physics** **(3-0) 3**
[MA 302; PH 321 or 322]

The production of low temperatures; temperature measurement; liquid helium; superfluids and superconductors; paramag-

netic salts; the magnetic temperature scale; nuclear polarization and alignment; thermal conductivity at low temperatures; the third law of thermodynamics; and adiabatic demagnetization.

PH 531 or 532 **Acoustics** **(3-3) 4**

Not offered in 1966-67.

PH 537 **Group Theory** **(3-0) 3**

Group theory and its application to the quantum theory, symmetry properties and conservation laws, crystalline fields, Lie groups, an analysis of the rotation and Lorentz groups, a general analysis of SU (n), and applications.

PH 552 **Astrophysics** **(3-0) 3**
[PH 206, PH 311]

The origin and future of the universe, using mathematical treatment wherever practicable. Theorems needed beyond the prerequisites are developed in the course.

PH 553 or 554 **Piezoelectricity and Ferroelectricity** **(3-3) 4**

Crystallographic bases of piezoelectricity, crystal elasticity, rotated axes, modes of vibration; behavior and interactions of the elastic, dielectric, and piezoelectric coefficients; ferroelectric crystals, domain structure, transitions between phases, free and clamped states; and applications of piezoelectric and ferroelectric crystals.

PH 555 or 556 **Plasma Physics** **(3-0) 3**
[PH 354]

The production of high-intensity electromagnetic and electrostatic fields and the interaction of these with conducting forms of matter. The physics of high-temperature, low-density gases, with emphasis on practical applications.

PH 557-558 **Electricity and Magnetism** **(3-0) (3-0) 6**
[MA 301-302, PH 353-354]

Electrostatics and magnetostatics with special attention to boundary-value problems. Quasistatic fields and displacement currents, Maxwell's equations, the Special Theory of Relativity, Lienard-Weichert potentials, and radiation from an accelerated charge. Waveguides, scattering, and applications to the problems of modern-day physics.

PH 561 or 562 **Nuclear Physics** (3-0) 3
[PH 462]

Stationary states of nuclei, nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles, gamma rays, and neutrons; nuclear forces and nuclear models; and fast neutron physics.

PH 563 or 564 **Microwave Spectroscopy** (3-3) 4

Not offered in 1966-67.

PH 565 or 566 **Nuclear and Electron Spin Resonance Phenomena** (3-0) 3
[PH 411-412 taken concurrently]

An introduction to crystal field theory and electron spin resonance; coupling of angular momenta; nuclear electric quadrupole and magnetic resonance; application to gases, liquids, and crystals; and a survey of experimental techniques.

PH 567 or 568 **Neutron Diffraction Analysis** (3-0) 3

The diffraction of neutrons in crystals and its applications in the determination of lattice structures and magnetic moments.

PH 571-572 **Lattice Imperfections** (3-0) (3-0) 6

A description of point, line, and plane imperfections in crystals, and their properties, causes, and interactions; the influence of imperfections on electron and phonon transport phenomena and also on lasers; a study of imperfections by X-ray and electron diffraction; and a discussion of problems in current literature.

PH 575-576 **Problems in Solid-State Physics** (3-0) (3-3) 7

Quantum mechanics and specific heats, lattice energy, elastic coefficients, applications of statistical mechanics, ferroelectric crystals, diamagnetism and paramagnetism, Brillouin zones, Hume-Rothery rules, order-disorder transformations, semiconductors, ferromagnetism and antiferromagnetism, ferrimagnetism, magnet relaxation and resonance, superconductivity, lattice vacancies, diffusion, color centers, excitons, dislocations, and thermal and electrical conductivity at low temperatures.

PH 577-578 **Thermodynamics of Solids** (3-0) (3-0) 6

The thermodynamics of first- and second-order phase changes; lattice energy and vibration spectrum; the Einstein-

Debye model; nonideal solid solutions; order-disorder phenomena; crystal interfaces and imperfections; and applications to metals and semiconductors.

PH 581 **Information Theory** **(3-0) 3**

A definition of information and its identifaction with entropy; a critical examination of codes and written and spoken languages; the Tuller-Shannon formula and the capacity of channels with noise; and autocorrelation techniques and their application. Physical analogs of communications problems are stressed throughout.

PH 583-584 **General Theory of Relativity** **(3-0) (3-0) 6**

The invariance of physical laws; tensor formulation of the special theory of relativity and applications; and the general theory of relativity.

PH 591-592 **Master's Thesis** **Credits to be arranged**

The thesis for the master's degree covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the department head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

PH 593-594 **Graduate Laboratory** **Credits to be arranged**

[Permission of instructor]

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics.

PH 595-596 **Physics Seminar** **Credits to be arranged**

A discussion of timely topics by visiting scientists, staff, and graduate students. Required of all graduate students.

PH 601-602 **Special Problems in High-Energy Physics** **Credits to be arranged**

PH 603-604 **Special Problems in Solid-State Physics** **Credits to be arranged**

PH 605-606 **Special Problems in Nuclear Physics** **Credits to be arranged**

PH 651-652	Physics Seminar in High-Energy Physics	Credits to be arranged
PH 653-654	Physics Seminar in Solid-State Physics	Credits to be arranged
PH 655-656	Physics Seminar in Nuclear Physics	Credits to be arranged
PH 701-702	Research in High-Energy Physics	Credits to be arranged
PH 703-704	Research in Solid-State Physics	Credits to be arranged
PH 705-706	Research in Nuclear Physics	Credits to be arranged

PLASTICS

PL 201-202 **Introduction to Polymeric Materials** **(2-0) (2-0) 4**

A descriptive subject to acquaint the student with plastics as a class of materials. The history, definitions, classes, properties, and applications of plastics.

PL 301-302 **Plastics Technology** **(2-2) (2-2) 6**

[PL 201 or permission of instructor]

Raw materials and manufacturing processes. Methods of processing plastics materials, including compounding, molding, casting, extruding, laminating, fabricating, and finishing. Evaluation and development of typical plastics problems. Laboratory instruction in the processing and fabrication of plastics materials.

PL 401-402 **Plastics Technology** **(2-3 (2-3) 6**

[PL 301-302]

Application of plastics as engineering materials. Product, equipment, and mold design. Correlation of composition, processing, and fabrication with product design and applications. Continuation of laboratory instruction in processing, molding, and fabrication.

PL 403-404 **Properties of Polymers** **(0-3) (0-3) 2**

[Open to seniors only]

Correlation of composition and structure with important engineering properties of plastics; environmental conditioning and effects of types of loading in evaluation of plastics materials; the theory of testing; critical examination of testing techniques, equipment, and standard ASTM methods of evaluating mechanical, thermal, electrical, and optical properties.

PL 411-412 **Plastics Seminar** **(1-0) (1-0) 2**

[Open to seniors only]

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics technology.

PL 413-414 Introduction to Polymer Physics (2-0) (2-0) 4

[Open to seniors only]

Chemical bonding in polymers, energy dispersion, segmental and molecular motion, freezing and melting, glass transition temperature, crystallinity, rubber elasticity, swelling, viscoelasticity, mechanics of network response, electrical and optical properties of polymeric networks, and of the physics of combined materials.

SOCIAL SCIENCES

SS 223 The United States: 1865-1912 (3-0) 3

With the unit approach, a study of the following: Political development from Reconstruction to the New Freedom, the rise of labor and industry after 1870, the rise of the West and its influence, diplomacy before World War I, and the social and cultural development of the American people.

Collateral readings will be required for each topic.

SS 224 The United States: 1912 to The Present (3-0) 3

[No prerequisite, but SS 223 is recommended as background]

Continuing the topical analysis of SS 223, a study will be made of the political philosophies from Wilson to Johnson, the industrial problems of the 20th Century, the transition from isolation to free world leadership, economic cycles, the impact of science, and current issues.

Collateral readings will be required for each topic.

SS 225 Europe: 1789-1914 (3-0) 3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and poltical reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 227 Europe: 1914-1939 (3-0) 3

A study of the quarter-century in which the "Great War" and the postwar settlements and realignments created a new Europe and set the stage for World War II. Emphasis is given to the rise of totalitarianism and the changing power patterns in Continental Europe and the world at large.

SS 228 Europe: 1939 to The Present (3-0) 3

A survey of the major events of World War II and the key factors in the postwar alignments. Particular attention is given to the roles of Soviet Russia and the United States, the effects of regionalism and internationalism, the decline of imperialism, and the economic, political, and social developments in the major nations in the period.

SS 301 Government of The United States (3-0) 3

A study of the structure of the national government with attention to the modern developments in the powers and functions of the three branches. Special emphasis is given to the making and implementation of both domestic and foreign policies.

SS 302 Conduct and Control of Foregin Policy (3-0) 3

A seminar considering the ways a state's conduct of its foreign policy affects, and is affected by, both the substance and processes of its domestic politics. Primary consideration is given to the United States and the principal nations of Western Europe, but examples are taken from other nations as well.

SS 303 or 304 Psychology (3-0) 3

The place of psychology in the life of the individual and society, with emphasis on the psychological bases of behavior and attitude in their relations to personal, industrial, and community experiences.

SS 305 or 306 Sociology (3-0) 3

The principles of sociology, including the development of man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 371 or 372 American Civilization to 1865 (3-0) 3

A study of the development of national consciousness in America through a review of the evolution of economic, political, and social institutions and their influences upon U. S. culture.

SS 403 Psychological Warfare in Foreign Policy (3-0) 3
[Approval of Instructor Required]

A seminar inquiring into the role of psychological warfare in modern foreign policy. Special attention will be given to such activities as economic aid, technical assistance, military missions, cultural exchanges, and information services.

SS 459 World Politics: The Central Problem of War (3-0) 3

War as the central phenomenon of world politics—its causes and functions in theory and history, its effects on the individual and society, efforts to control it, and ethical problems raised by it.

SS 460 Foreign Aid and Foreign Policy (3-0) 3

A seminar considering the difficulties involved in stabilizing areas threatened by communism and insurgency which lie outside the line of containment. Discussions involve changing approaches to foreign aid, and relations of western powers, Congress and the State Department, and various other departments and agencies involved in foreign policy operations.

SS 464 World Politics: Problems of International Organization (3-0) 3

International and regional organizations both as mirrors of contemporary world politics and as forces of change. The history and theories of international organization, constitutional problems, the political and non-political functions of the UN system; the development, varieties, and significance of regionalism; and the relations between traditional and parliamentary diplomacy.

SS 471 The United States in World Politics (3-0) 3

The principles behind American foreign policy and an eclectic inquiry using a case study into the circumstances under which these principles have been utilized by the United States.

SS 472 Defense Policy (3-0) 3

A seminar revolving around the relationship of force and foreign policy in the thermonuclear age. Discussions involve policymaking and organization, military strategy and foreign policy, and the substance of natural security.

SS 477 or 478 Twentieth-Century Russia (3-0) 3

The objective of this subject is twofold: to give the student an understanding of the Russian people, the Empire, and the Soviet Union through a study of backgrounds, and to make possible a comprehension of the structure, aims, and methods of the Soviet regime and its present role in world affairs.

SS 479 or 480 The Far East Since 1900 (3-0) 3

Basic historical and cultural backgrounds of the peoples of East Asia surveyed as a preface to a study of the economic, political, and social development of the mainland and island states, with emphasis on the interests and policies of European nations and the United States.

SS 481 or 482 The Greeks and Western Civilization (3-0) 3

Contributions of the ancient Greeks to our culture. The in-

fluences of Greek thought, arts, and politics studied through selected readings and discussions in seminar meetings.

SS 483 Political and Social Thought: Ancient Times to Early Modern Times (3-0) 3

Studied in the works of great writers of political and social philosophy from Plato through Machiavelli. Class discussion with the purpose of tracing the origins and development of humanism, asceticism, communism, fascism, and democracy.

SS 484 Political and Social Thought: Early Modern Times to Present (3-0) 3

Studies in the origins and development of modern political and social ideologies. Class discussion with the purpose of relating ideologies to institutional conflicts.

SS 485 or 486 The Romans and Western Civilization (3-0) 3

Roman contributions to western culture and politics, with emphasis on Roman legal and governmental concepts and institutions.

SS 487 American Political Thought to 1865 (3-0) 3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0) 3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and the postwar years.

SS 489 or 490 Nationalism and Imperialism Since 1800 (3-0) 3

The origins and development of nationalism and imperialism and the effects of these phenomena upon the nations of Europe. Attention is given to interpretations of these subjects as well as to historical events. A written assessment of the significance of these phenomena in the modern period is required.

SS 492 Twentieth Century Germany (3-0) 3

Political development, social and military history, and conflicts of the "-isms" in Germany from the founding of the Second Empire to West Germany's assumption of a position in the NATO Alliance. Relation of the nation's past to current

problems of re-unification, international position, and internal economic and political stability will be stressed.

SS 494 Totalitarian Systems of The 20th Century (3-0) 3

A study of the problem of totalitarianism with regard to both theory and practice in the present century. The origins, characteristics, and influences upon man and society will receive particular attention. A semester paper, on a subject selected by the student from an approved list, is required.

TEXTILE CHEMISTRY

TC 201 — Introduction to Textiles — (2-0) 1

The history, economics, and geographical distribution of the textile industry and its interrelationships with the chemical and fiber-producing industries. The basic principles, nomenclature, and sequences of the physical and chemical processes of the textile industry.

TC 202 — Chemistry and Physics of Fibers — (3-0) 3

The structure and chemical reactions of linear high polymers of importance in the field of natural and synthetic fibers; the chemical and physical structure of polymers and fibers; the relation of molecular length, orientation, crystallinity, intermolecular attractions, side chains, and flexibility of polymers to the physical properties of fibers; and chemical reactions of polymers and their effects on fibers.

TC 301 — The Purification of Fibers — (2-3) 3

The chemical and physical nature and properties of impurities in natural and man-made fibers and the mechanisms of their elimination. The theory and principles of fiber purification discussed in lectures are evaluated by laboratory and pilot-plant experimental study.

TC 311 — Chemical Textile Testing — (3-0) 3

Qualitative and quantitative methods for determining fiber content, finishing agents, and dyestuffs, including optical methods of analysis and evaluation.

TE 403 — The Principles of Dyeing and Printing — (2-6) 4

The principles of dyeing and printing commercially important fibers with the more important classes of dyes and pigments. Lectures, laboratory experimentation, and pilot-plant problems are integrated to illustrate basic principles of dyeing methods, color prediction, compatibility of dyes in mixtures, basic variables of machine design, the control of nonuniformity, and the principles of phase transfer of dyes in printing.

TC 404 — Theory of Dyeing — (3-4) 4

Mechanisms of reactions in the dyeing of fibers which emphasize basic physical and chemical variables affecting equi-

libria, rates of dyeing, and diffusion. Quantitative studies on the kinetics and equilibria of dyeing reactions are conducted in the laboratory.

TC 411 Chemical Technology of Finishing I (3-1) 3

Conversions of fabrics from the gray state for utility, serviceability, or appearance. Stress is placed both on the chemical phases and on essential engineering principles. Lectures, seminars, and laboratory workshops.

TC 412 Chemical Technology of Finishing II (3-2) 4

Continuation of TC 411.

TC 502 Theory of Dyeing (3-4) 4

[For Graduate Students]

Same as TC 404 but with added assigned reading and reports.

TC 505 Physical Chemistry of Dyeing (3-0) 3

Lectures and exercises on the physiochemical principles involved in the application of dyestuffs to textile materials, including both the thermodynamics and kinetics of dyeing.

TC 541-542 Graduate Thesis Credits to be arranged

An independent investigation of a problem in textile chemistry in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

TEXTILES

TE 206 **Textile Physics** **(3-0) 3**

[PH 104]

A comprehensive study of the principles of mechanics, mechanism, and optics as they relate to industrial use in general and textiles in particular.

TE 212 **Fiber Science** **(3-1) 3**

The different fibers and their origin and properties. The effect of molecular arrangement in fibers upon the chemical, physical, and mechanical behavior of the raw material and upon their technological utilization. Polymer structure, order, intermolecular forces, flexibility, and other properties in the light of stress-strain relationships, such as viscoelastic behavior. These and other factors as design elements leading to the prediction of the physical properties of textile systems, as well as the geometry of yarns and fabrics and their behavior characteristics.

TE 311 **Fiber Science** **(3-1) 3**

[Same as TE 212]

Available only to Juniors, Seniors, Graduate Students and with permission of the Department Head.

TE 361 **Technology of Yarns** **(3-1) 3**

[TE 212]

[May be taken concurrently with TE 311 with permission of Department Head.]

The preparation into yarn of staple cellulosics and man made fibers on the cotton system as well as filamentous man made fibers. These are presented analytically in terms of engineering principles or mechanisms concerned with functional use, structural design, and basic geometry of the yarns.

TE 362 **Technology of Yarns II** **(3-1) 3**

[TE 361]

Same as TE 361 but involving wool in woolen or worsted yarn systems or blends of same with natural and synthetic fibers. A consideration of recovery processes for use of waste in varied fabrics is included.

TE 363 **Textile Systems I** **(3-1) 3**

[TE 212]

Fiber preparation processes as systems in yarn manufacture presented analytically in terms of engineering principles or mechanisms leading to an understanding of the functional use, structural design, and basic geometry of yarns. All fiber systems are included.

TE 364 **Textile Systems II** **(3-2) 3**

[TE 363]

The concepts of fabric design: an analysis of the effects of mechanical processing upon structural relationships, with stress on physicomechanical and chemical behavior.

TE 366 **Textile Systems III** **(3-0) 3**

[TE 364]

A study and analysis of the physical behavior of gray fabrics as mechanical systems during the finishing operations. Major emphasis is on absorption, pressure, heat transfer, and the physical and mechanical design principles involved.

TE 411-412 **Fundamentals of Textiles — Yarns** **(2-2 (2-2) 6**

[TE 363 or equivalent]

Designed to familiarize students with the basic machines and techniques for the production of yarns regardless of the fibers and/or production systems used. Primary emphasis is upon the mechanical principles employed.

TE 431-432 **Fundamentals of Textiles — Fabrics** **(2-2 (2-2) 6**

[TE 364 or equivalent]

Designed to familiarize students with the basic machines and techniques for the production of fabrics regardless of the fibers and/or yarns employed, from the preparation of yarns for fabrication to the actions and modifications available for the production of fabrics. Primary emphasis is upon the mechanical principles employed.

TE 433-434 **Technology of Knitting** **(2-1) 2**

[TE 363 or equivalent]

Recommended as technical elective for TE-EN.

A broad survey of the mechanics of knitting equipment and the varied fabrics produced therefrom.

TE 435 **Advanced Fabric Technology** **(3-1) 3**

[TE 364 or equivalent]

A thorough study of design and weaving as applications of science to the construction of fabrics.

TE 457-458 **Technology of Finishing** **(3-0) (1-2) 5**

[TE 364 or equivalent]

Lectures and laboratory workshop in the major engineering and chemical considerations necessary to convert greige fabrics to their finished state. Engineering aspects including heat transfer principles are stressed.

TE 467 **Textile Systems IV** **(1-2) 2**

[TE 366]

The basic chemical structure of the fibers within the fabric and the relationship which such a system has with the application of dye and finish due to chemical transition catalysis, electrostatic attraction, covalent and other bonding forces, etc., in effecting an acceptable end product.

TE 472 **Textile Evaluation** **(2-3) 3**

[TE 364 or equivalent]

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 474 **Instrumentation for Textiles** **(2-2) 3**

[PH 205 or equivalent]

A study of some mechanical, electrical, and electronic methods for the measurement and control of such common textile process variables as pressure, temperature, liquid level, and fluid flow. The response of sensing elements, the modes of control, the characteristics of final control elements, and the inter-relationship between those in closed loop systems are considered.

TE 482 **Application of Scientific Methods to Textile Processes** **(3-0) 3**

[PH 205, MA 206, ME 216]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483*-484* **Engineering Design of Textile Structures** **(3-0) (3-0) 6**

[MA 205, TE 364]

This subject correlates engineering properties of textile materials, engineering principles, and textile processing in the design of textile structures with desired properties. Graphical solutions are considered. The geometry of yarns, fabrics and wire cloth; design of textile structures for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes which the end use imposes; analyses of load-elongation diagrams of textile structural material.

TE 485* **Statistical Quality Control — Textile** **(3-0) 3**

[MA 383, TE 364 or equivalent]

A study of statistical and administrative techniques relevant to the maintenance of product quality at defined levels. Sampling plans for variables and attributes are considered from the viewpoint of engineering economics.

TE 501-502 **Textile Polymer Science** **(3-0) (3-0) 6**

[Permission of Instructor]

The morphological, macromolecular, and molecular structure of fibers are considered as a basis for an understanding of various performance characteristics. The latter include stress-strain relationships in the non Hookian region, time dependent parameters primary and secondary creep, as well as the effect of environmental conditions on these parameters. Critical analysis of performance characteristics are used as a means of selection of fibers as structural units in the design of items having defined performance requirements. An introduction is made to the interrelation between fiber properties and yarn and fabric geometry in determining the behavior of textiles.

TE 503 Technology of Novel Cellulosic Substrates (2-2) 3
[Permission of Instructor]

Systems for handling and methods of utilizing cotton waste products, modified cottons, non-woven textile structures in the production of novel fabrics. The effects of various chemical, mechanical and growth modifications of cotton on the chemical, physical and processing properties of cotton fiber. Problems are assigned for laboratory evaluations and a written report for oral presentation is required.

TE 517 Product Quality (2-2) 2
[Permission of Instructor]

Product defects in the manufacture of spun yarns are studied and analyzed. Procedures necessary to avoid the defects are studied and the diagnostic ability of the student to recognize and remedy defects is developed with the aid of case histories.

TE 519 Multifiber Processing: Yarns (3-2) 3
[Permission of Instructor]

The processing of man-made fibers into spun yarns using different yarn systems is studied with emphasis upon fiber and yarn properties and involving engineering principles. Blending techniques are covered for various fibers including both man-made and natural fibers.

TE 571 Microscopy of Fibrous Materials and Assemblies (2-3) 3
[Permission of Instructor]

A consideration of the principles involved in the selection and use of appropriate optics as well as manipulative and preparative techniques for the qualitative and quantitative estimation of morphological, physical, and chemical properties of fibrous materials and assemblies. Observations are interpreted with the objective of eliciting information relevant to engineering applications.

TE 573 Mechanical Testing of Textiles (2-3) 3
[Permission of Instructor]

Thickness and compressional measurements, stress-strain-time phenomena of viscoelastic textile materials, Vibroscope theory and techniques, yarn uniformity, thermal determination, and friction evaluation are among the major topics covered. Emphasis is placed on current literature search assignments and

the preparation of a student paper on a selected topic within the scope of the subject.

TE 581 **Textile Management and Costing** **(3-0) 3**
[Permission of Instructor]

Management principles and techniques applied to problems in textile administration; production, scheduling and routing; sales forecasting; inventory control; materials; machine and labor costing; budgeting; management recruiting and training; internal and external organization relations case histories used to supplement course coverage. Several textbooks available.

TE 583 **Textile Automation** **(3-0) 3**
[Permission of Instructor]

Engineering approach to the study of the present automated textile manufacturing and production processes from fiber to finished fabric and their impact on management, labor, and cost factors. Research and problems relating to the degree of automaticity for better control of mass and flow production in the industry will be required and implemented with present trends.

TE 585 **Textile Plants Organization — Yarns** **(3-0) 3**
[Permission of Instructor]

Designed to correlate the various aspects of yarn production. Emphasis is placed upon the need for proper balance among machinery elements for the production of specific yarn types. Consideration of machinery layouts for efficient and economic operation of the total yarn establishment, with stress on the various calculations involved. Considerable use is made of the case history technique of presentation.

TE 587 **Textile Plants Organization — Fabrics** **(3-0) 3**
[Permission of Instructor]

Similar in concept to TE 585 except that the subject pertains to the production of fabrics.

TE 589 **Central Management and Business Policies** **(3-0) 3**
[TE 581, Permission of Instructor]

New concept of managementation occurring in business today. Analytical framework for sifting and relating elements involved in the operational environment of the whole company; less reliance placed on intuitive grasp of factors affecting business policy formulation; the critical job of central manage-

ment under this changing emphasis included as it affects various aspects of business case histories prepared, discussed and analyzed.

TE 592 **Graduate Seminar** **(2-0) 0**

Introduction to thesis material and thesis preparation.

TE 593-594 **Thesis Seminar** **Two hours per week No credits**

Required of all graduate students in Textile Technology. Devoted to problems in the preparation and presentation of research work, with illustrative material drawn from thesis work in process.

TE 595-596 **Graduate Thesis** **Credits to be arranged**

Each graduate student in Textile Technology is required to submit a thesis which shows ability and originality in the solution and presentation of a research project.

THE GRADUATE SCHOOL

INTRODUCTION

The Lowell Technological Institute Graduate School, founded in 1935, offers graduate programs in the following areas:

Master of Science Programs

Chemical Engineering	Paper Engineering
Chemistry	Physics
Electrical Engineering	Textile Chemistry
Mathematics	Textile Technology

Doctor of Philosophy Programs

Chemistry
- **a.** polymer science
- **b.** organic
- **c.** physical

Physics
- **a.** experimental
- **b.** theoretical

Because of the varied objectives of the graduate students, each specific course of study is arrived at through consultation with the student's graduate advisory committee. Each program includes an original thesis.

ADMISSION

General Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training are considered. Selection of applicants admitted is based upon their ability to pursue graduate work of high quality.

Special Student Status

An applicant who meets the general admission requirements but who wishes to concentrate on specific subjects or special research programs may request special student status. Acceptance is contingent upon the consent of the instructor in charge

of each subject to which admission is desired, and the work does not lead to a degree.

Normally a special student may not change his status to that of a student working for a graduate degree. If a special student wishes to work for a degree, he must apply in writing to the Director of the Graduate School. If the application for change in status is approved, all of the credit earned as a special student may not necessarily be allowed for degree credit.

Provisional Status

An applicant for admission who is unable to meet all the requirements for general admission may be accepted provisionally if he satisfies the department in which he wishes to enroll that he is probably able to pursue graduate studies successfully.

The status of a provisional graduate student may be changed to full graduate status upon demonstration of his ability to pursue graduate studies successfully as measured by the completion of his first semester's work with a minimum of a B— average in subjects taken for credit toward the graduate degree.

Application Procedure

Applications may be obtained from the Office of the Graduate School. They should be completed and returned to the Director of the Graduate School not later than June 1 preceding the fall term in which the applicant wishes to enroll. Applications must be supported by letters from at least two persons qualified to judge the ability of the applicant to carry on graduate work and research. The letters should be sent directly from these persons to the Graduate School.

Transcripts of all undergraduate records (and graduate, if any) must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with appropriate seals and signatures. Records, descriptions of subjects, and letters must be in English. Each subject must be described in terms of content, scope, number of hours per week, and number of weeks duration. Lecture and laboratory time should be properly distinguished. If a catalogue giving such descriptions in English is available, the subjects taken may be clearly marked in a copy sent to the Graduate School.

Credit may be given for graduate subjects taken at other colleges if the grade received is at least B and if these subjects were not used in earning another degree. All applicants must submit an additional copy of transcripts which include the subjects for which transfer credit is desired. Not more than 10 credit hours for the master's degree or more than 22 credit hours

for the doctor's degree may be transferred. No transfer credit can be offered for the thesis requirement for any graduate degree. Transfer credit for subjects taken at other colleges before initial enrollment at Lowell Technological Institute must be cleared within four weeks after the student's first registration. No transfer credit for such subjects is given after this period.

In addition to returning a completed application form and having transcripts and letters sent, the applicant must take the Graduate Record Aptitude Test and have the results sent to the Director of the Graduate School. Information regarding the Graduate Record Aptitude Test may be obtained from Educational Testing Service, 20 Nassau Street, Princeton, N. J., or Box 27896, Los Angeles 90027, Cal., whichever office is nearer to the applicant. All fellowship applicants must also take the appropriate Advanced Test administered by the Educational Testing Service.

Because most subjects are presented in lecture form, students from other countries should have a reasonably fluent command of the English language before applying for admission. All students from countries where English is not the national language must pass the "Test of English as a Foreign Language" (TOEFL) examination administered by the Educational Testing Service. Information regarding the test may be obtained from TOEFL, Educational Testing Service, Princeton, New Jersey 08540, U.S.A.

Except in unusual circumstances, applications are acted upon and the applicant is notified of the decision by July 1. Foreign applicants are urged to apply as early as possible so as to leave enough time for visa and other arrangements to be made.

ACADEMIC EXPENSES

Tuition (per year)	
U. S. citizens who are residents of Massachusetts	$200
All others	$600
Student Activity and Insurance Fund (per year)	49
Commencement Fee	15

In addition, every graduate student is required to bear the cost of binding at least two copies of his thesis for the Institute's files. Some divisions may require more than two bound copies. Students are not permitted to register for thesis work until these fees have been paid at the library.

Graduate students who have previously registered for the number of thesis credits required for their degrees, but who, in order to complete their theses, must do further work requiring the use of laboratory facilities, must pay a tuition charge based

on the number of credit hours determined in each case by the appropriate department head.

Graduate students who have completed all degree requirements except the writing and defense of a thesis, and who do not need to carry out further laboratory work to complete the thesis, are exempt from any tuition charges. If such students remain on campus, they must register their presence with the Graduate School office.

AFROTC

Graduate students or upperclassmen who will have a minimum of two years remaining at the Institute may participate in AFROTC under the same conditions and with the same benefits as outlined on page 64 for the two year AFROTC program.

FELLOWSHIPS

No special applications are required, but students who wish to be considered for fellowships must have their completed graduate school application material, including transcripts and letters of reference, sent to the Director of the Graduate School no later than April 1.

All fellowship applicants must take the appropriate Advanced Graduate Record Examination as well as the Aptitude Tests on or before the March examination date.

Teaching Fellowships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends are approximately $3000 per academic year, the exact amount depending on the nature of the appointment. Reappointment in succeeding years is contingent upon satisfactory performance of duties. Appointees are expected to carry up to a half-time, teaching load primarily involving supervision of undergraduate laboratories and review sections.

Research Fellowships

The Lowell Technological Institute Research Foundation sponsors a limited number of research fellowships for graduate study in Physics. A stipend of $2500 plus tuition and fees is granted for one calendar year. The recipient carries a full graduate program during the fall and spring semesters and conducts his thesis investigation during the summer.

National Science Foundation Graduate Traineeships

The National Science Foundation has awarded several grants to the Institute for the support of a limited number of Graduate

Trainees in Physics. The Traineeships are awarded on the basis of ability. Candidates must be citizens of the United States on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute prior to beginning their Traineeship tenures. Grants may be extended to cover a three year period of doctoral studies.

The stipends provided by the NSF for Graduate Traineeships are $2400 for those on a tenure of twelve months and $1800 for those on a tenure of nine months. There is also an allowance of $500 for each dependent. Additional income for limited teaching activity up to $1000 is available. Tuition and fees are paid by the NSF directly to the Institute.

National Aeronautics and Space Administration Graduate Traineeships

The National Aeronautics and Space Administration has awarded a grant to the Institute for the support of a limited number of predoctoral Graduate Trainees in space related areas of Physics. The stipends and dependency allowance are virtually identical to the NSF Traineeships described above. Tuition and fees are paid by the NASA directly to the Institute.

Textile Salemen's Association of New York Fellowship

A graduate fellowship in textiles is awarded by the Textile Salesmen's Association of New York, based on academic accomplishment and demonstrated ability. The award is limited to full-time students working toward the MS degree in Textile Technology who plan to continue working in the field of textiles in this country after graduation.

MASTER OF SCIENCE DEGREE PROGRAMS

CHEMICAL ENGINEERING

The graduate program in chemical engineering is designed to provide the opportunity for further studies in the fundamentals and application of chemical engineering principles and to carry out independent research work in the field of chemical engineering.

The Chemical Engineering Department will consider students for enrollment in the course of graduate studies who fulfill the requirements:

1. Students who have a Bachelor of Science degree in chemical engineering from a recognized school, or
2. Students who do not have a Bachelor of Science degree

in chemical engineering, but who have made up or will make up deficiencies in their training so that they can show proficiency equivalent to a Bachelor of Science degree in Chemical Engineering from Lowell Technological Institute.

Required Subjects For The M.S. Degree

1. CHE 501-502 Graduate Thesis **8 credits**
2. A minimum of **12 credits** in Chemical Engineering subjects chosen from the following list.
3. A minimum of **9 credits** in Technical Electives chosen from the following list.
4. A minimum of **30 credits** in Thesis, Chemical Engineering and Technical Electives is required to fulfill the requirements of a Master's degree in Chemical Engineering.

Chemical Engineering Subjects

CHE 503 or 504	Absorption and Extraction	(3-0) 3
CHE 505 or 506	Colloid Chemistry for Chemical Engineers	(3-0) 3
CHE 507	Corrosion and Electrochemical Principles	(2-0) 2
CHE 509	Mathematics for Chemical Engineers	(2-0) 2
CHE 511 or 512	Structure and Properties of Matter	(3-0) 3
CHE 513	Advanced Economic Balance	(3-2) 4
CHE 517 or 518	Advanced Distillation	(3-0) 3
CHE 523 or 524	Advanced Chemical Process Analysis	(3-0) 3
CHE 525 or 526	Advanced Heat Transfer	(3-0) 3
CHE 530-531	Chemical Engineering Seminar	(1-0) (1-0) 2
CHE 532 or 533	Applications of Computers	(2-3) 3

Technical Electives

CH	503-504	Chemistry of High Polymers	(3-0) (3-0) 6
CH	512	Physical Chemistry of Surface-Active Agents	(3-0) 3
CH	513	Chemical Applications of Spectroscropy and Spectrophotometry	(3-0) 3
CH	514	Physicochemical Methods	(2-0) 2
CH	538	Rheology	(3-0) 3
CH	540	Chemical Kinetics	(3-0) 3
EC	414	Engineering Economy	(3-0) 3
MA	301-302	Functions and Their Applications	(3-0) (3-0) 6
ME	383 or 384	Statistical Methods	(3-0) 3
ME	493-494	Industrial Instrumentation	(2-0) 2

Thirty credits are required for the M.S. degree, but additional undergraduate subjects may be required of students who have deficiences in their prior training. Technical electives must be approved by the Head of the Department of Chemical Engineering and Paper Engineering.

Chemistry

This program provides opportunity for advanced study and research training in chemistry, both general and specialized. Provision also is made for the student to elect certain advanced subjects in related fields of mathematics, physics, and engineering.

Evaluation Examination—During the weeks of registration each entering student must present himself for the four three-hour written evaluation examinations in the fields of organic chemistry, physical chemistry, inorganic chemistry, and analytical chemistry. In addition he must take a laboratory proficiency examination. These examinations are scheduled and administered by the Department of Chemistry, and the results serve as a guide for the student and advisory committee in planning the program of study. All entering students must take these examinations regardless of previous training.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis and seminar, required in listed subjects (see Re-

quirements for Graduation) a minimum of 15 credits must be taken in chemistry. Of these not more than 12 credits may be taken in approved undergraduate subjects, although normally credit is not allowed for undergraduate subjects in the major field of specialization, e.g., organic, physical, inorganic. Recommended subjects include CH 423-424*, CH 431-432*, CH 443-444*, CH 515, CH 516 and all 500 subjects in chemistry. Each graduate program must include subjects in organic chemistry, inorganic chemistry, and physical chemistry. All students must take CH 507-508, Chemistry Seminar. The remaining credits (five or more) may be taken in chemistry or in a related field such as physics, mathematics, or engineering. All subjects must be approved by the student's advisory committee.

Language Requirements—The student must demonstrate his ability to read technical German. For details concerning the language examination, see the section on Doctor of Philosophy Degree Program.

Advisory Committee—The development of the student's program of study is the responsibility of an advisory committee consisting of three members from the faculty of the Division of Chemistry and Applied Chemistry.

The Committee moreover has the prerogative of maintaining continuing surveillance over the aptitude and performance of the student under its direction through periodic conferences, and should it find that the student's capability and potential are below graduate school standards, it may recommend to the Department Head that the student be dismissed. This committee is appointed by the Director of the Graduate School upon the recommendation of the division chairman and includes the thesis supervisor.

Thesis Examination—Each candidate for the Master of Science degree in Chemistry, upon completion of his thesis, must present himself for an oral examination in the field of his thesis before an examination committee appointed by the department head and consisting of his advisory committee and other appropriate faculty members. While only members of the examination committee and the Director of the Graduate School may conduct the examination, all faculty members may attend. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the last semester. Each student has the right to one re-examination within a period of one year.

Electrical Engineering

This graduate program offers to a limited number of selected students opportunity for individualized work in the more advanced areas of electronics with emphasis on analytic methods of analysis and synthesis.

Mathematics (see Physics and Mathematics)

PAPER ENGINEERING

This program provides for advanced study and research training in Paper Engineering and allied subjects, with specific application to papermaking and paper converting.

The Paper Engineering Department will consider applicants in the following categories:

(a) graduates of the Lowell Technological Institute B.S. Paper Engineering program;
(b) BS graduates in Paper Engineering or Paper Technology from other universities;
(c) general BS or MS graduates in Engineering or Chemistry with no previous training in Paper Engineering.

Required Subjects for the M.S. Degree

1. PA 501-502 Graduate Thesis **8 credits**
2. A minimum of **12 credits** in Paper Engineering subjects chosen from the following list.
3. A minimum of **9 credits** in Technical Electives chosen from the following list.
4. A minimum of 30 credits in Thesis, Paper Engineering and Technical Electives is required to fulfill the requirements of a Master's degree in Paper Engineering.
5. Additional undergraduate subjects may be required of students who have deficiencies in their prior training. Technical electives must be approved by the Head of the Department of Chemical Engineering and Paper Engineering.

Paper Engineering Subjects

PA	503-504	Advanced Converting Processes	(3-0) (3-0) 6
PA	505	The Physics of Paper	(3-0) 3
PA	506	New Techniques in the Paper Industry	(2-0) 2
PA	508	Advanced Paper Systems Analysis	(2-0) 2
PA	509-510	Paper Engineering Seminar	(1-0) (1-0) 2

Technical Electives

CHE	407	Engineering Analysis of Chemical Processes	(3-0) 3
CHE	408	Engineering Materials	(3-0) 3
CHE	410	Process Analysis and Design	(3-0) 3

All graduate CHE subjects

CHE	503-504	Chemistry of High Polymers	(3-0) (3-0) 6
CH	512	Physical Chemistry of Surface-Active Agents	(3-0) 3
CH	538	Rheology	(2-0) 2
CH	540	Chemical Kinetics	(3-0) 3
EC	414	Engineering Economy	(3-0) 3
MA	383 or 384	Statistical Methods	(3-0) 3
ME	493 or 494	Industrial Instrumentation	(2-0) 2

Physics and Mathematics

The graduate programs in Physics and Mathematics provide an opportunity for advanced study and the development of research capacity in physics or mathematics. The laboratories of the department are well set up for investigations in crystal physics, and other aspects of solid-state physics, with excellent equipment in X-rays, spectroscopy, and electron microscopy. Equipment in nuclear physics is constantly being added.

Subject Requirements—Of the 20-credit minimum, exclusive of thesis, required in listed courses (see Requirements for Graduation) 15 credits must be taken in physics and mathematics. The remaining credits (five or more) may be taken in a related field. Of the total credits at least 12 must be in subjects numbered 500 and above. A reasonable and consistent program of study is prepared by the student and his advisory committee. This committee consists of two or more members from the faculty of the Division of Physics and Engineering Science, one of whom is the thesis supervisor. The committee is appointed by the department head. Entering students who are found to be deficient in any areas of the undergraduate curriculum in Physics may be required to take appropriate courses in that curriculum.

Language Requirements—The student must demonstrate his ability to read technical German or Russian.

Thesis Examination—Each candidate for the Master of Science degree in this department, upon completion of his thesis, must present himself for an oral examination in the field of his thesis to an examination committee appointed by the department head and consisting of his advisory committee and other appropriate faculty members. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the last semester. Each student has a right to one re-examination within a period of one year.

Textile Chemistry

The graduate program in Textile Chemistry provides opportunity for advanced study and research in chemistry as applied to textiles and textile auxiliary agents. Formal subjects and research facilities are provided for training in fiber science and in the chemistry of the various processing operations applied to fibers, yarns, and fabrics, including dyeing, finishing, and fiber modifications. Each student upon entering the curriculum must take the evaluation examination in physical chemistry given at a specified time during the week of registration as described in the section relating to the Master of Science program in Chemistry.

The MS degree in Textile Chemistry normally requires two years for completion except in those instances where the student possesses previous training in this field sufficiently extensive to meet departmental standards.

First Semester

CH	331	Physical Chemistry	(3-3) 4
MA	383	Statistical Methods	(3-0) 3
TC	301	The Purification of Fibers	(2-3) 3
TC	403	The Principles of Dyeing and Printing	(2-6) 4
TC	411	Chemical Technology of Finishing I	(3-1) 3
		Total hours	(13-13) 17

Second Semester

CH	332	Physical Chemistry	(3-3) 4
CH	334	Colloid Chemistry	(3-0) 3
TC	202	Chemistry and Physics of Fibers	(3-0) 3
TC	412	Chemical Technology of Finishing II	(3-2) 4
TC	502	Theory of Dyeing	(3-4) 4
		Total hours	(15-9) 18

Third Semester

CH	501	Interpretation of Data	(3-0) 3
TC	505	Physical Chemistry of Dyeing	(3-0) 3
TC	541	Graduate Thesis	5
TE	571	Microscopy of Fibrous Materials and Assemblies	(2-3) 3
		Total credit hours	14

Fourth Semester

CH	502	Absorption Spectrophotometry and Color Measurement	(2-3) 3
CH	512	Physical Chemistry of Surface-active Agents	(3-0) 3
CH	538	Rheology	(3-0) 3
TC	542	Graduate Thesis	5
		Total credit hours	14

Depending upon previous baccalaureate preparation, exemptions on some of the above subjects may be allowed. However, no exemptions will be allowed on any graduate subject (subjects with numbers in the 500's).

Textile Technology

This graduate program is offered to qualified students in the field of textiles, with primary emphasis upon either the engineering or physical aspects of the field. Ample opportunity is afforded for study and research in the physical and mechanical properties of fibers and textile structures and methods of evaluating them. Work at an advanced level on the structural design of textiles, processing principles, and manufacturing equipment is also available. Applicants should have a BS degree in Textile Engineering or Technology, Mechanical Engineering, or Electrical Engineering. Applicants with degrees in other areas, however, are given consideration.

Diagnostic Examinations—All entering students who have had previous training in Textile Technology are required to take diagnostic examinations during registration week. The subject areas tested are Fundamentals of Yarns, Fundamentals of Fabrics, Finishing Statistics, and Statistical Quality Control. Students are required to take diagnostic examinations only in subjects in which they have had previous training. Those who demonstrate proficiency in diagnostic examinations are exempt from taking the corresponding subjects during their program at the Institute.

Subject Requirements—The following suggested curriculum is recommended for most students. Those who demonstrate proficiency in diagnostic examinations are exempt from taking the corresponding subjects. Students whose background is deficient in engineering or mathematics are required to take additional subjects.

First Semester

MA	383	Statistical Methods	(3-0) 3
TE	311	Fiber Science	(3-1) 3
TE	411	Fundamentals of Textiles—Yarns	(2-2) 3
TE	431	Fundamentals of Textiles—Fabrics	(2-2) 3
TE	433	Technology of Knitting	(2-1) 2
TE	457	Technology of Finishing	(3-0) 3
		Total hours	(15-6) 17

Second Semester

TE	412	Fundamentals of Textiles—Yarns	(2-2) 3
TE	432	Fundamentals of Textiles—Fabrics	(2-2) 3
TE	458	Technology of Finishing	(1-2) 2
TE	472	Textile Evaluation	(2-3) 3
TE	474	Instrumentation for Textiles	(2-2) 3
TE	592	Thesis Seminar	(2-0) 2
		Total hours	(11-11) 14

Third Semester

TE	483*	Engineering Design of Textile Structures I	(3-0) 3
TE	501	Textile Polymer Science I	(3-0) 3
TE	593	Thesis Seminar	(2-0) 0
TE	595	Thesis	3
		Electives	6
		Total credit hours	15

Fourth Semester

TE	484*	Engineering Design of Textile Structures II	(3-0) 3
TE	502	Textile Polymer Science II	(3-0) 3
TE	594	Thesis Seminar	(2-0) 0
TE	596	Thesis	3
		Electives	6
		Total credit hours	15

Electives are to be chosen from those available in any one semester from the 500 series of textile subjects.

Electives are arranged in blocks and no two will be chosen from the same block in any one semester.

Although most electives will end in an odd digit, it may be available in either semester.

Elective Blocks

I	II	III
TE 571	TE 503	TE 581
TE 573	TE 517	TE 583
	TE 519	TE 585
	TE 485*	TE 587
		TE 589

Thesis Examination—Each candidate for the Master of Science degree in Textile Technology, upon completion of his thesis, must take an oral examination in the field of his thesis. This examination is conducted by a committee appointed by the Director of the Graduate School which must include the thesis supervisor and advisers of the candidate and any additional faculty members desired by the Director. Any faculty members may attend, but only members of the examination committee may conduct the examination. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the semester in which the student expects to be a candidate for the degree. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the designated semester. If the student fails the oral examination, he has the right to one re-examination within a period of one year. Failure in the re-examination requires the satisfactory completion of a new thesis subject and the accompanying oral examination.

MASTER OF SCIENCE DEGREE REQUIREMENTS

Term of Residence

Applicants with sufficient background in their chosen field of concentration normally require one academic year of residence to complete the requirements for the master's degree. Those with no background require a minimum of two years of residence.

Graduates of other colleges usually need more than one academic year to fulfill the degree requirements, even though they majored as undergraduates in their graduate field of specialization.

All requirements for the master's degree must be completed within five years after the student's entrance. Extension of time beyond this limit may be granted only with joint approval of the student's adviser (or advisory committee), his department head, his division chairman, and the Director of the Graduate School.

Requirements for Graduation

To be recommended for the Master of Science degree a candidate must:

1. Complete a course of study approved by the department in which he has been enrolled. The approved course of study must have a minimum of 30 credit hours, including thesis. A minimum of 20 credit hours must be spent in listed subjects, and the program should have no fewer than five credit hours of thesis work.
2. Complete a thesis (original research or other investigation, optional with the department) approved by the department in which he has been enrolled, and successfully pass any oral or written examinations on his thesis required by the department at the time his thesis is submitted for final approval. The only grades given for thesis work are S (satisfactory) and U (unsatisfactory). All theses should be submitted in final form to thesis advisers on or before May 15.
3. Maintain residence for at least one academic year.
4. Maintain at least a B— average in all work in formal subjects offered for the degree. The lowest grade acceptable for graduate credit is C. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work but which are taken during his enrollment as a graduate student must be passed with a grade of at least C; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.
5. Fulfill departmental language requirements.
6. Satisfy all requirements as to tuition and fees.

PH.D. PROGRAM IN CHEMISTRY

Objectives

The doctoral program in chemistry is designed to provide the student with a background in advanced course work and chemical laboratory techniques that will prepare him to carry out, under the guidance of experienced scientists, an original, independent investigation that will lead to an acceptable contribution to the body of contemporary chemical knowledge.

Plan of Program

The doctoral degree normally requires from three to four years of study beyond the bachelor's degree or a minimum of two to three years beyond the master's degree.

The plan of study pursued by each student is dependent on individual requirements and is developed through conference with his advisory committee or, pending its appointment, with his temporary adviser.

All students entering the doctoral program must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in Chemistry. Only those students who have taken these examinations previously as candidates for the Master of Science program will be excused.

The initial part of the student's program, normally completed at the end of two years of study, is devoted to formal course work. His first year is usually given to subjects in the major branches of chemistry in preparation for his qualifying (candidacy) examinations. The second year is devoted primarily to advanced subjects in a special field of concentration in preparation for the comprehensive examinations.

The second and final part of the program is devoted principally to research leading to the doctoral thesis. However, the student is encouraged to begin research as early as possible in his program of study.

Upon entrance to the doctoral program, each student is assigned an advisory committee. This committee is appointed by the Director of the Graduate School, based upon recommendation by the Chairman of the Division of Chemistry and Applied Chemistry, and consists of at least three members of the faculty. Of these at least two must be from the faculty of the Division of Chemistry and Applied Chemistry. One member of the committee representing the student's major field of interest serves as temporary chairman. After the student has selected his thesis supervisor, the temporary chairman of the advisory committee

is replaced by the thesis supervisor, who then serves as permanent chairman.

The committee is responsible for the development of the student's program. It moreover has the prerogative of maintaining continuing surveillance over the aptitude and performance of the student under its direction through periodic conferences, and should it find that the student's capability and potential are below Doctoral standards it may recommend to the Department Head that the student transfer to the Master of Science program or if circumstances warrant, be dismissed.

Examinations for Doctoral Students in Chemistry

Qualifying Examinations—Three written qualifying examinations are given by the Chemistry Department, each involving one full day. These examinations cover the fields of organic chemistry, physical chemistry and inorganic-analytical chemistry. Before the student can be admitted to candidacy for the doctorate, he must pass all three examinations.

Qualifying examinations are given in all fields twice each year, in September during or before the week of registration and in June following the final examination period. All three qualifying examinations must be attempted not later than the beginning of the third semester of graduate study in the doctoral program (normally in September of the second year), though any one or all may be attempted earlier. In cases of failure, re-examinations may be taken only during the June period. A second failure in any one of the examinations results in automatic dismissal from the doctoral program. All qualifying examinations must be passed before the beginning of the third year in the program.

The comprehensive examination is in two parts, a written examination lasting one day and covering the field of the major, and an oral examination in defense of a proposition.

The written examination is given once a year in September. It should be taken as soon as possible after completion of the bulk of course work in listed graduate subjects in the field of specialization. However, it must be taken not later than the beginning of the fourth year of study in the doctoral program. Where it is necessary to carry less than the normal credit load of 12+ per semester, the student must apply for extension beyond this deadline to the chairman of the division through the chairman of his advisory committee.

Comprehensive Examinations—The comprehensive examination consists of two parts: a written examination and the oral defenses of a proposition. The written examination is scheduled for one full day and encompasses the entire field of the major.

The oral examination on the proposition is directed primarily to the research topic submitted but may include relevant background material.

The proposition represents a thesis in miniature without laboratory work. With the aid and advice of his advisory committee the student selects a subject suitable for investigation, completes a literature survey, outlines the method of approach, and suggests possible results and conclusions. He is then required to defend his proposition by oral examination. The examination is conducted by the student's advisory committee and with other faculty members of the department in attendance.

Prior to the oral examination and at least one month before the scheduled date of the written comprehensive examination, the student must file with the chairman of his advisory committee three written copies of his proposition, presented in the form generally prescribed for a thesis. The oral defense of the proposition is presented after the written comprehensive examination, and permission to take the oral examination is contingent on first passing the written test.

The request to take both qualifying and comprehensive examinations must be initiated by the student. The request is made to the advisory committee, and the chairman of that committee then submits a written recommendation to the division chairman that the examination be given. The examination schedule is published well in advance of the date set, and the student must file the request with his advisory committee at least one month before the scheduled date. The deadline normally is 5 P.M., May, 1, for the June examinations and 5 P.M. on the last day of classes in the second semester for the September examinations.

Thesis Examination—Upon completion of his doctoral research, the candidate must present himself for oral examination on his thesis. Permission to take this examination must be sought through the advisory committee chairman to the division chairman and is granted only after all candidacy requirements have been met and the comprehensive examinations passed.

Language Examinations—A candidate for the doctorate must demonstrate by examination ability to read technical literature in two foreign languages. One foreign language must be German. The second language is generally French or Russian. Proficiency in English is a requirement for foreign students, and the department reserves the right to establish this proficiency by examination if such action is indicated.

Language examinations are scheduled in November and in March. The student must present himself for examination in at

least one language at each scheduled examination period until the complete language requirement has been fulfilled.

Course Offerings and Distribution

As a basis for the candidacy examinations the following core of subjects is recommended for the first-year students in the doctoral program:

CH	423-424*	Advanced Organic Chemistry	(3-0) (3-0) 6
CH	431-432*	Advanced Physical Chemistry	(3-0) (3-0) 6
CH	443-444*	Advanced Inorganic Chemistry	(3-0) (3-0) 6
CH	515	Advanced Laboratory Technique	(1-3) 2
CH	516	Chemical Literature	(1-0) 1
CH	564	Organic Qualitative Analysis	(1-6) 3

If the results from the diagnostic examinations indicate adequate background in any of the above subjects, substitution by a more advanced subject in the 500 series is recommended. Full graduate credit is allowed in the 400 subjects listed above except that credit will not be allowed in CH 423-424 for organic chemistry majors and in CH 431-432 for physical chemistry majors, even though these may be recommended. Additional subjects in chemistry or in the field of the minor may be taken in the first year if desired, provided the prerequisites are met.

In the second year, subjects supporting concentration in specific fields are available as follows:

Organic Chemistry

CH	513	Chemical Applications of Spectroscopy and Spectrophotometry	(3-0) 3
CH	514	Physicochemical Methods	(2-0) 2
CH	521-522	Physical Organic Chemistry	(3-0) (3-0) 6
CH	527-528	Stereochemistry	(3-0) (3-0) 6
CH	553	Organic Chemistry of Macromolecules	(3-0) 3
CH	554	Stereochemistry of Macromolecules	(3-0) 3
CH	561-562	Advanced Organic Synthesis	(3-0) (3-0) 6
CH	567	Steroid Chemistry	(3-0) 3

CH	565	Metal-Organic Compounds	(3-0) 3
CH	566	Heterocyclic Chemistry	(3-0) 3

The core of subjects recommended for majors in organic chemistry includes CH 521-522, CH 527-528, and CH 561-562. Majors in organic chemistry must also meet a requirement in physical chemistry comprising the course sequence CH 539-540.

Physical Chemistry

CH	531-532	Statistical Mechanics for Chemists	(3-0) (3-0) 6
CH	533-534	Quantum Mechanics for Chemists	(3-0) (3-0) 6
CH	535-536	Advanced Topics in Physical Chemistry	(3-0) (3-0) 6
CH	537	Advanced Chemical Thermodynamics	(3-0) 3
CH	539	Theoretical Chemistry	(3-0) 3
CH	540	Chemical Kinetics	(3-0) 3
CH	556	Physical Chemistry of Surfaces	(3-0) 3

Chemistry Seminar

During each year of residence the student is required to attend and to participate in CH 507-508, Chemistry Seminar, (1-0) (1-0) 2.

Majors and Minors

The prospective candidate, is expected to supplement his training in the major field of interest by electing a minor. The minor should represent a minimum of 12 credits and may be divided between two fields of study. The minor program may be selected from chemistry subjects outside the major field of interest, as well as from approved advance subjects in physics, mathematics, or engineering.

Polymer Science Option

Students in the PhD program in Chemistry may elect an option in Polymer Science. This optional program is designed to provide both knowledge in depth of the special physical and chemical behavior of macromolecular substances and a sound background in physical and organic chemistry to serve as a foundation for research training and experience in high polymer.

The plan of the program and the examination system is the same as that previously described except that the set of evaluation examinations taken upon entrance to the program includes

an additional examination in polymer science and the comprehensive examinations are in this same field.

It is recommended that the first year student take the following subjects:

CH	423-424*	Advanced Organic Chemistry	(3-0) (3-0) 6
CH	431-432*	Advanced Physical Chemistry	(3-0) (3-0) 6
CH	503-504	Chemistry of High Polymers	(3-0) (3-0) 6
CH	505-506	Techniques of Polymer Chemistry	(0-4) (0-4) 2
CH	516	Chemical Literature	(1-0) 1

It is moreover recommended that CH 443-444* Advanced Inorganic Chemistry (3-0) (3-0) 6 and CH 564 Organic Qualitative Analysis (1-6) 3 be taken in the first or second year unless these subjects have been taken previously. Full graduate credit is allowed in the 400 subjects listed above excepting CH 431-432.

The core of subjects recommended for the second and third year follows:

Polymer Science

CH	521-522	Physical Organic Chemistry	(3-0) (3-0) 6
CH	527-528	Stereochemistry	(3-0) (3-0) 6
CH	539	Theoretical Chemistry	(3-0) 3
CH	540	Chemical Kinetics	(3-0) 3
CH	551-552	Physical Chemistry of Macromolecules	(3-0) (3-0) 6
CH	553	Organic Chemistry of Macromolecules	(3-0) 3
CH	554	Stereochemistry of Macromolecules	(3-0) 3
CH	555	Polymer Physics	(3-0) 3
CH	556	Physical Chemistry of Surfaces	(3-0) 3

Recommended electives include CH 531-532, Statistical Mechanics; CH 538, Rheology; and MA 433* or 434* Matrix Algebra.

REQUIREMENTS FOR PH.D. DEGREE IN CHEMISTRY

Term of Residence

Only work done during the regular academic year from September to June is counted toward residence credit. A minimum of one full academic year of study in residence is required of all candidates. A full year constitutes not less than 36 credit hours of work. Semesters in residence should be consecutive if possible.

All requirements for the doctorate must be completed within seven years after the student's entrance and within four years after admission to candidacy. Extension of time beyond this limit may be granted only with the joint approval of the student's advisory committee, his department head, his division chairman, and the Director of the Graduate School.

Candidacy for the Doctorate in Chemistry

To be admitted to candidacy for the doctorate, a student must:

1. Complete the first year's core of recommended subjects and have a satisfactory record in undergraduate training, graduate seminar, and collateral reading.
2. Pass the qualifying examinations which test his general knowledge. One day each is devoted to an examination in the following areas: organic chemistry, physical chemistry, and combined inorganic-analytical chemistry.
3. Fulfill the language requirements.
4. Secure the approval of his advisory committee and the division chairman.

When these requirements have been fulfilled, the division chairman notifies the Director of the Graduate School in writing and recommends that the student be placed on the list of candidates for the Ph.D. degree. Admission to candidacy in no way guarantees the granting of the degree.

Requirements for Graduation

To be recommended for the Doctor of Philosophy degree in Chemistry a candidate must:

1. Satisfy the residence requirements.
2. Pursue an approved program of study that includes the satisfactory completion of at least 90 credit hours beyond the bachelor's degree, or equivalent. At least half

of these credits must be in formal course work exclusive of seminars or thesis.

3. Maintain at least a B— average in all work in formal subjects offered for the degree. The lowest grade acceptable for doctoral credit is C—. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work but which are taken during his enrollment as a graduate student must be passed with a grade of at least C—; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgment of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.

4. Demonstrate satisfactory reading ability in German and one other language (preferably French or Russian). Foreign students may under certain circumstances substitute their native tongue for one of these languages. Both language examinations must be passed prior to advancement to candidacy and before extensive work on the thesis is begun.

5. Pass the qualifying examinations for candidacy.

6. Pass the major examinations in the field of concentration. These examinations primarily test the student's knowledge in his special field of concentration and draw heavily on knowledge gained during his second full year of study in that particular area. They are given only when substantially all of the formal course work has been completed, normally at the end of the second full year (fourth semester). The major examination is in two parts. The first part is written and extends over a period of one day. It tests the student's broad knowledge in his specific field. The second part of the major examination is oral and tests the student's aptitude for research and his ability to organize and to develop a research problem. The examination takes the form of the defense of a proposition. The student selects a problem with the approval of his advisory committee.

7. Complete a satisfactory thesis. The doctoral thesis is designed to permit the student to demonstrate his ability to conduct original and independent research work. Results of the thesis investigation should constitute a definite contribution to knowledge in the field of spe-

cialization and should be suitable for publication. The field of the thesis investigation should be selected as soon as possible after admission to the graduate program, and the subject of the thesis must be approved by the advisory committee. As soon as the subject has been selected, the student must make his choice known to the department head, who in turn notifies the Graduate School so that the list of theses in progress may be kept current. The thesis subject must be filed not later than two weeks after the student has been admitted to candidacy. The thesis normally constitutes about half of the total credit requirement and, as a rule, requires three to four semesters of full-time work.

8. Pass a thesis examination. This is an oral defense of the student's thesis before the faculty of the Department of Chemistry.
9. Satisfy all requirements as to tuition and fees.

PH.D. PROGRAM IN PHYSICS

A research program in both theoretical and experimental physics leading to the degree of Doctor of Philosophy in Physics is offered in the following fields: Theoretical Physics, Solid-State Physics, Nuclear Physics, Electron Device Physics, and Atomic and Hyperfine Spectroscopy.

Objectives

The doctoral program in Physics is designed (**a**) to provide the student with a thorough training in classical and modern physics and (**b**) to advance the student to the level where he can successfully carry out independent experimental and theoretical work in problems of modern-day physics.

Plan of Program

An incoming graduate student is assumed to possess a sound background in intermediate-level mechanics, electricity and magnetism, statistical mechanics, thermodynamics, and modern physics. Accordingly, a typical graduate curriculum would be drawn from the following subjects:

First Year

MA	505-506*	Mathematical Methods of Physics	(3-0) (3-0) 6
PH	471-472*	Solid-State Physics	(3-0) (3-0) 6

PH	511*	Classical Mechanics	(3-0) 3
PH	515-516	Quantum Mechanics	(3-0) (3-0) 6
PH	521*	Statistical Mechanics	(3-0) 3
PH	557-558*	Electricity and Magnetism	(3-0) (3-0) 6

Second Year

PH	537	Group Theory	(3-0) 3
PH	561	Nuclear Physics	(3-0) 3
PH	575-576	Problems in Solid-State Physics	(3-0) (3-0) 7
PH	593-594	Graduate Laboratory	

Third and Fourth Years

PH	517	Advanced Quantum Mechanics	(3-0) 3
PH	519	Theory of Weak Interactions	(3-0) 3
PH	555	Plasma Physics	(3-0) 3
PH	583-584	General Theory of Relativity	(3-0) (3-0) 6
PH	601-606	Special Problems	
PH	701-706	Doctoral Thesis	

Subjects marked with an asterisk are ordinarily required and may be waived for the incoming student only at the discretion of the department head. A student whose background is deficient in one or more areas may require subjects in these areas his first year. However, such subjects may not be taken for graduate credit toward the Ph.D. degree.

Examinations for Doctoral Students in Physics

Preliminary Examination—Prior to the second semester of his second year the candidate must have achieved a satisfactory score, to be determined by the graduate faculty, in the Graduate Record Examination in Physics. The candidate has three chances to achieve this score; however, he must notify the department head prior to taking the examination.

Ph.D. Qualifying Examination—Prior to the second semester of his third year the student must have taken the Ph.D. Qualifying Examination. The examination itself consists of

both a written and oral part, given, if the need demands, three times a year—in September, January, and June. The written examination consists of two four-hour examinations, given on successive days, testing the student's understanding of graduate-level material in the following subjects: Classical Mechanics, Classical Electricity and Magnetism (including Special Relativity), Quantum Mechanics (on the level of Schiff), Statistical Mechanics, Thermodynamics, Nuclear and Atomic Physics, and Mathematical Methods of Physics. The oral examination, given by the staff shortly thereafter, is directed by a committee selected from the faculty.

If the candidate fails on his first attempt, he must repeat the examination no later than September of his fourth year. If he fails a second time, he may no longer be considered a candidate.

Successful completion of the qualifying examination requires passing grades in both oral and written parts.

Final Examination—The candidate must pass a final oral examination administered by his thesis committee and other faculty members. This examination consists mainly of a defense of the results of his thesis but may also include background and other material at the discretion of the committee.

Requirements for Graduation

Requirements for the degree of Ph.D. in Physics are as follows:

1. **Residency**—A minimum of two years of full-time residency (18 credits per year). However, in the case of a candidate who enters the Institute with a master's degree in Physics, the requirement is two years **or** one year subsequent to achieving a satisfactory score in the Ph.D. qualifying examination. In addition, no degree will be awarded to a candidate in less than three years if he enters with a bachelor's degree, or in less than two years if he enters with a master's degree.

2. **Grade Average**—A grade average of at least B— must be maintained in all graduate subjects offered for the degree. The lowest grade acceptable for doctoral credit is C—.

3. **Foreign Language**—The candidate must demonstrate to the satisfaction of the graduate faculty his reading proficiency in two of the following three languages: French, German, Russian.

4. **Examinations**—The candidate must pass the preliminary, qualifying, and final examinations.

5. **Thesis**—The candidate must conduct original research leading to a thesis, indicating his ability to carry out independent research on the doctoral level. This thesis must be unanimously approved by a thesis committee of three members of the faculty. The candidate's thesis adviser is a member of this committee.

6. **Tuition and Fees**—All tuition and fee requirements must be satisfied.

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LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Mass.

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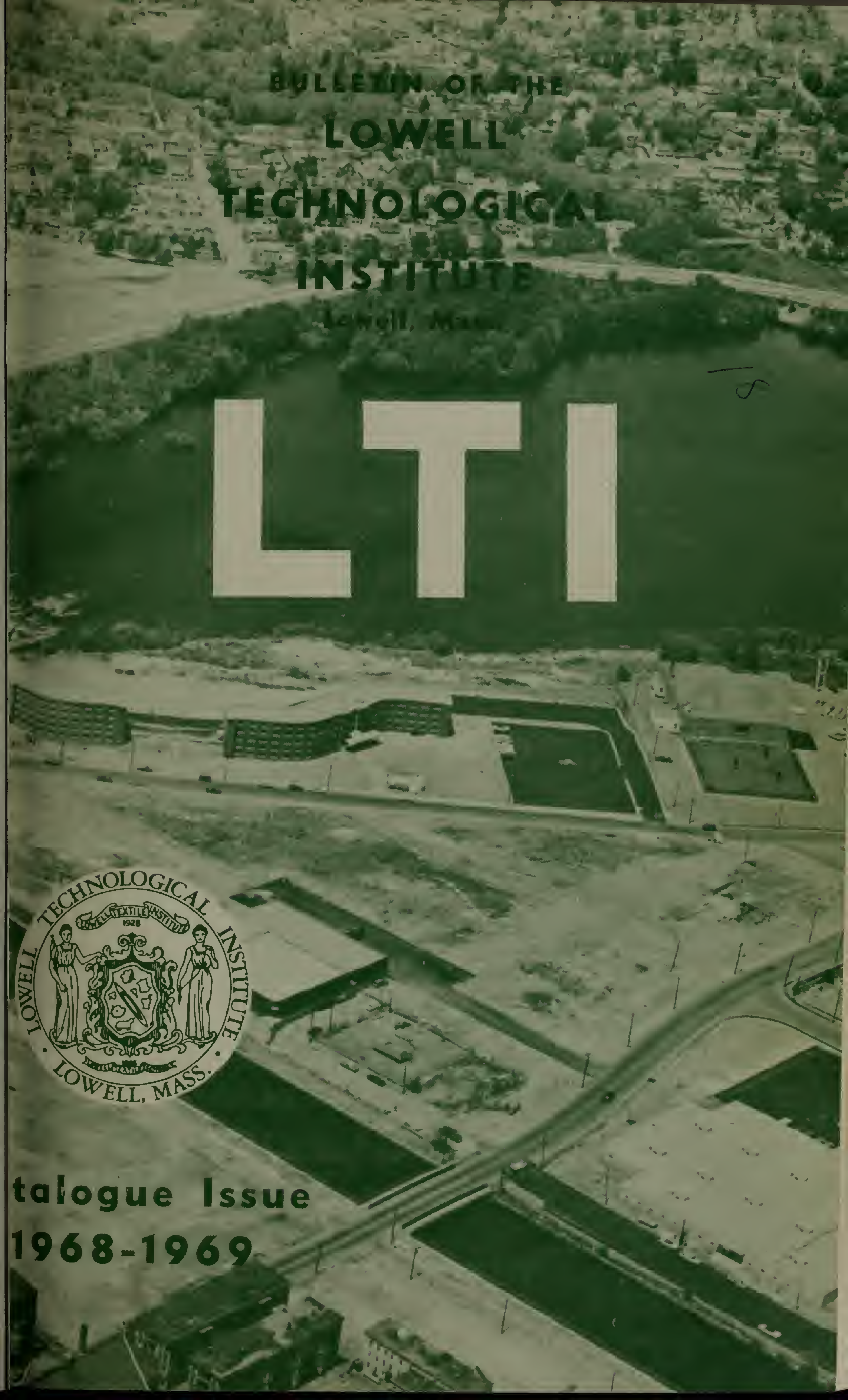

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DIRECTORY

Further information concerning these subjects may be obtained by writing to the following sources:

Admissions	Director of Admissions
Scholarship aid	Dean of Students
Official transcripts	Registrar
Graduate studies	Director of Graduate School
Summer school	Director of Summer School
Evening study program . .	Director of the Evening Division
Alumni affairs	Alumni Office
Graduate placement . . .	Placement Director
Library industrial corporate membership	Librarian
Conferences, special programs, public relations	Director of Public Relations
Sponsored research	Lowell Technological Institute Research Foundation

See supplement for late course changes and additions.

LOWELL TECHNOLOGICAL INSTITUTE

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LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Massachusetts 01854

Established 1895

Operated by the Commonwealth of Massachusetts

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Total enrollment—6600
Day Division—2675
Evening Division—2600
Summer School—1350

Men and women students from 20 states and 30 countries

Tuition: $200 for U. S. citizens who are residents of Massachusetts
$600 for all others

L.T.I. Research Foundation conducts research and development work for government and industry.

The main campus lies between Mass. Route 113 and the VFW Highway along the bank of the Merrimack River, one-half mile north of the center of Lowell, 25 miles north of Boston.

Office hours: 8:30 a.m.—5:00 p.m., Monday through Friday

Telephone number: 454-7811 (Area Code 617)

* * *

The Board of Trustees reserves the right to waive, at its discretion, any of the rules and regulations stated herein and to change any of the subjects or curricula, or portions thereof, without prior notice.

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ACADEMIC CALENDAR, 1968 - 1969

September 9, Monday	Registration of graduate students begins. Freshman Orientation Week begins.
September 11, Wednesday	Registration of sophomores.
September 12, Thursday	Registration of juniors.
September 13, Friday	Registration of seniors.
September 16, Monday	Classes begin.
September 23, Monday	Last day to register for new classes.
October 1, Tuesday	No classes after 1 p.m. Field Day activities. (Tentative)
October 11, Friday	No classes. Columbus Day Observance.
October 14, Monday	Last day to drop classes without penalty.
November 11, Monday	Institute closed. Veterans Day.
November 27, Wednesday, 1 p.m.	Thanksgiving recess begins.
December 2, Monday	Classes resume.
December 20, Friday, 6 p.m.	Christmas recess begins.
January 6, Monday	Classes resume.
January 20, Monday, 9 a.m.	Examinations begin.
January 27, Monday	End of first semester.
February 4, Tuesday	Registration of sophomores.
February 5, Wednesday	Registration of juniors and graduate students.
February 6, Thursday	Registration of seniors.
February 7, Friday	Registration of freshmen.
February 10, Monday	Classes begin.
February 17, Monday	Last day to register for new classes.
February 18, Tuesday	Institute Closed. Washington's Birthday Observance.
March 10, Monday	Last day to drop classes without penalty.
March 28, Friday, 6 p.m.	Spring recess begins.
April 7, Monday	Classes resume.
April 21, Monday	Institute closed. Patriots Day Observance.
May 6, Tuesday	No classes. Upstream Day. (Tentative)
May 19, Monday	Last day for submitting graduate theses.
May 26, Monday	Institute closed. Memorial Day Observance.
June 2, Monday	Second-semester examinations begin.
June 9, Monday	End of second semester.
June 15, Sunday	Commencement

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James E. Stone, B.S. (Springfield College), Instr., Physical Education

Elwood W. Streeter, B.S. (Lowell Technological Institute), Lect., Electrical Engineering

Aruthur D. Talkington, B.S. (University of Chicago), M.A. (University of Missouri), Asst. Prof., Mathematics

Virginia S. Taylor, B.S. (Syracuse University), M.A. (Western Michigan University), Asst. Prof., Mathematics

Ye-Yung Teng, B.S. (National Taiwan University, China), M.S. Ph.D. (University of Maryland), Instr., Physics

Major Nicholas Theochares, USAF, B.S. (Springfield College), Asst. Prof., Aerospace Studies

Henry E. Thomas, B.T.E. (Lowell Technological Institute), P.E. (Massachusetts), Prof., Plastics Technology

George J. Toscano, B.S., M.B.A. (Northeastern University), C.P.A., Assoc. Prof., Economics and Management

Col. Charles L. Vacanti, USAF, B.S. (University of Nebraska), M.A. (University of New Mexico), Head of Department and Prof., Aerospace Studies

David P. Wade, B.S. (Lowell Technological Institute), M.S. (Northeastern University), Asst. Prof., Electrical Engineering

David A. Wagenknecht, B.A., M.A. (Boston University), Instr., Languages and Literature

Francis R. Walsh, B.S., M.A. (Boston University), Asst. Prof., Social Sciences

Tso-Chou Wang, Dip. in Eng., D.Eng. (Technische Hochschule, Germany), Assoc. Prof., Mechanical and Textile Engineering

Joseph W. Waterman, B.S. (University of Vermont), M.B.A. (Boston University), Asst. Prof., Social Sciences

Aruthur C. Watterson, Jr., B.S. (Geneva College), Ph.D. (Brown University), Asst. Prof., Chemistry

Harold L. Wedlick, B.S., M.S. (Wayne State University), Assoc. Prof., Radiological Sciences

Louis I. Weiner, B.S. (Temple University), M.S. (Lowell Technological Institute), Visiting Prof., Textile Technology

Robert J. Whelan, B.S. (Boston College), M.A. (Catholic University of America), Asst. Prof., Languages and Literature

Francis J. Weidenmann, A.B., M.S. (Rutgers University), Visiting Asst. Prof., Radiological Sciences

Roger E. Wiehe, B.A. (Yale University), M.A. (University of Illinois), Ph.D. (Columbia University), Assoc. Prof., Languages and Literature

Joyce W. Williams, B.A. (University of Minnesota), M.S., Ph.D. (University of Illinois), National Teaching Fellow, Mathematics

Martin Wilner, B.S. (Rensselaer Polytechnic Institute), M.S. (Yale University), Ph.D. (Massachusetts Institute of Technology), Asst. Prof., Physics

Charles R. Wilson, B.S. (Lowell Technological Institute), Instr., Chemistry

Albert T. Woidzik, B.S. (Lowell Technological Institute), P.E. (Massachusetts), Assoc. Prof., Textile Technology

Chuen Wong, Dip. of Science (Chung Chi College, Hong Kong), Ph.D. (Case Institute of Technology), Instr., Physics

Francis T. Worrell, B.S. (University of Michigan), M.S., Ph.D. (University of Pittsburgh), Prof., Physics

Waldo W. Yarnall, B.S. (University of Vermont), Director of Athletics

Professors Emeriti

Horton Brown, B.S.

William G. Chace, Ph.B., M.S.

Harold C. Chapin, A.B., A.M., Ph.D.

Lester H. Cushing, A.B., Ed.M., Sc.D.

James G. Dow, A.B.

Charles A. Everett, B.T.C.

Elmer E. Fickett, B.S., Sc.D.

C. Leonard Glen

Martin J. Hoellrich

Nathaniel E. Jones

James H. Kennedy, Jr., B.T.E., M.S.

Gilbert R. Merrill, B.T.E.

John L. Merrill, B.T.E.

John H. Skinkle, S.B., M.S.

A. Edwin Wells, B.T.E., M.Ed., P.E.

ADMINISTRATIVE ASSIGNMENTS

President's Office

Elizabeth P. Kennedy, CPS, Secretary
Helen G. Flack, Secretary

Assistant to the President's Office

Kleonike J. Bentas, Secretary

Provost's Office

Mary F. Perkins, Secretary

Admissions Office

Alice R. Redican, Clerk
Diane L. Goodrich, Secretary
Gladys M. Coughlin, Clerk

Building and Power

George F. Abodeely, LLB, Administrator
Charles F. Johnson, Superintendent of Building and Grounds Maintenance
Charles DeFillipo, Plant Engineer

Business Office

Richard F. Connolly, Business Office Manager
Wilfred J. Brodeur, Bursar
Michael J. Chory, Accountant
George S. Zaharoolis, Accountant
John L. Sayer, Supervisor of Payroll
Gerald F. Cronin, Administrative Assistant
James Sullivan, Administrative Assistant
William L. Kelly, Housing Officer
Patricia J. Gallagher, Bookkeeper
Edna Nestor, Bookkeeper
Mary C. Sullivan, Bookkeeper
Irene D. Burns, Clerk
Anita V. Lacie, Clerk
Joan Cinq-Mars, Clerk
Helen Shanahan, Clerk
Gloria Willman, Clerk
Judith A. Wood, Secretary

Data Processing

William J. Keenan, Director
Dolores Trudel, Statistical Machine Operator

Dean of Faculty's Office

Theresa D. Leblanc, Secretary

Dean of Students' Office

Barbara Jean Maccaron, Secretary

Division of Chemistry and Applied Chemistry

Harriet E. Burns, Secretary
Mona M. Davis, Secretary
Frank B. Ridge, Chemical Storekeeper

Division of Evening Studies

Aristomenes G. Panos, B.S. in B.A., Recorder
Emma M. Millette, Secretary
Marguerite H. McGarry, Secretary
Kathryn Sheehy, Secretary

Division of General Studies

Joanne M. Poitras, Secretary
Jeannette L. Savard, Secretary

Division of Physics and Engineering

Eleanor M. McKenna, Secretary
Judith Brennan, Secretary
Karen I. Volis, Secretary
Leo F. Patenaude, Electronic Equipment Supervisor

Financial Aid

Walter A. Costello, B.S., Officer

Graduate School Office

Carole L. Cormier, Secretary

Guidance

Leo F. King, Jr., A.B., Ed. M, Assistant to the Dean of Students
Vittoria Rosatto, B.S., Counselor

Health Services

Arlene D. Gordon, R.N., In Charge
Janet E. Connors, R.N.

In Service Training Program

John J. Delmore, Hon. Sc. D., Administrative Assistant
Doris A. Spinney, Secretary

Libraries

Howard K. Moore, A.B., A.M., Ph.D., Director
Joseph V. Kopycinski, B.S., M.S., M.S. in Library Science, Librarian
Vera Boyd Meehan, B.S., Assistant Librarian
Charles F. Donaldson, Library Assistant
Mary P. Frascarelli, Library Assistant
Eleanor T. Lessard, Library Assistant
Madeline M. Owens, Library Assistant
Ann V. Pendergast, Library Assistant
Doris R. Sullivan, Library Assistant
June E. Traverse, Library Assistant

Placement Office

James A. Brennan, A.B., M.B.A., LL.B., Director

Receptionist

Lorraine I. LeDoux

Registrar's Office

Frank J. Duggan, Jr., A.B., Registrar
Nora M. MacBrayne, Secretary
Mary P. Kloppenburg, Clerc
Mabel M. Murphy, Clerk
Catherine P. Ouellette, Clerk

Summer School

Ernest P. James, B.T.C., M.S., Director

GENERAL INFORMATION

History

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry.

In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, mathematics, nuclear science, nuclear engineering, industrial management, business administration and meteorology.

In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to the Lowell Technological Institute. The Institute grants Bachelor of Business Administration, Bachelor of Science, Master of Science, and Doctor of Philosophy degrees.

Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

Accreditation

The Institute is a member of the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends accreditation to the curricula in electrical, mechanical, and textile engineering, and the chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. Although the majority of its students are men, the Institute is co-educational.

Campus
The campus is situated 25 miles north of Boston, Massachusetts, in Lowell, a city of nearly 100,000, long famous as a textile center and more recently for its increasingly diversified industries. The 29-acre campus, situated on both sides of the Merrimack river, includes 13 main buildings, among them an auditorium-administration building, a library which is currently being greatly enlarged, six classroom-laboratory buildings, four residence halls and a gymnasium. A $4,500,000 nuclear science center is under construction.

Alumni Memorial Library
The library, dedicated to Alumni of the Institute who served in World Wars I and II and the Korean conflict, was erected in 1951 by the Alumni Association through contributions from the alumni and friends. It contains student activity offices, an alumni headquarters and houses one of the world's most complete collections of textile books as well as numerous special collections in the fields of paper, leather and plastics. It also serves as a depository for U. S. government publications and is available to industrial concerns through its Industrial Corporate Membership program. An addition currently under construction will increase library seating capacity from the present 172 to 1200, and the volume capacity from 80,000 to 400,000.

Equipment
Laboratory equipment used in the instructional and research programs of the Institute is valued at more than $12,000,000. It includes such varied apparatus as an electron microscope, analog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, plastics, leather, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Admissions Office has received senior grades for this period. The responsibility of having these marks forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure not less than 12 months in advance of the expected date of enrollment.

The institute does not accept part time or special students, nor does it accept students at mid-year.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Director of Admissions, Lowell Technological Institute, Lowell, Mass. 01854.

Applications for admission must be received by the Institute on or before June 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is in need of financial assistance may request an application for a loan under the National Education Defense Act or an application for scholarship aid AFTER he has been accepted for admission to Lowell Technological Institute.

Application Procedure

A candidate for admission should:

1. Complete the first two pages of the admission application form.

2. Attach a certified check or money order in payment of the application fee of $10 which is not refundable.

3. Submit the entire application form to the office of the secondary-school principal, with a request that the office fill out pages 3 and 4 and mail the completed application directly to the Director of Admissions.

4. Request transcripts be sent to Lowell Technological Institute from any college, preparatory school, or institution of learning beyond secondary school attended.

5. Make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test which is required of ALL applicants for admission to the freshman class at the Institute. The applicant must take the Scholastic Aptitude Test during the senior year in secondary school or thereafter. Letters, telephone calls, etc., will not be accepted in place of the official score card.

Applicants for admission who are in the upper 20% of their high-school class scholastically may be admitted by the Director of Admissions prior to completion of the CEEB examinations. This examination, however, must be completed during the senior year and the results forwarded to Lowell Technological Institute before final acceptance is granted.

6. Undergo a complete health examination by a family physician. The physician must return to the Student Health Services on a form provided by the Institute, a certificate of good health, indicating the date of the examination. Health certificates are not sent to the applicant until he has been finally accepted by the Institute.

7. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of the place of residence. This certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

8. Upon receipt of a letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll.

Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition.

If an applicant plans to attend the Institute, after receiving final acceptance letter he should instruct the secondary school to send a transcript of final grades to the Admissions Office after graduation.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus days. Personnel from the Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. They will be held on February 14, 1968, April 15, 1968 and October 25, 1968 commencing at 10:30 a.m. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the

final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Entrance Certificate Board, the Regents of the State of New York, or a board of equal standing.

2. For all courses except Business Administration a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiency in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration a candidate must have completed 16 units of approved high-school work:

English	4 units
mathematics	2 units
American history and social studies	2 units
laboratory science	1 unit
electives	7 units

as well as the Scholastic Aptitude Test. Candidates should also indicate the choice of this program on the top right-hand corner of the formal application form.

Advanced Placement

See Pages 30 - 31.

Students from Other Countries

All foreign applicants for whom English is a second language and who have been in the United States for less than two years must take an English proficiency test and have the results sent

to the Director of Admissions prior to filing a formal application with the Institute. The test used by the Institute to determine English proficiency is TOEFL (Test of English as a Foreign Language). Students should arrange to take this examination by writing to the Educational Testing Service in Princeton, New Jersey, 08540, U. S. A. and, as stated above, request the results be sent to Lowell Technological Institute.

The Institute accepts every year foreign applicants in numbers up to 5% of each entering class. In all other respects, the admission procedure for foreign students is the same as that required of U. S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, in ENGLISH, and not less than twelve months in advance of the expected date of enrollment. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U. S. students.

To facilitate their adjustment to campus life, all freshman male students from other countries are required to live in the Institute's residence halls and are assigned to rooms shared by U. S. students. Students must supply their own towels, sheets, pillows and pillowcases, and blankets or may subscribe to a laundry service. Bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.

TRANSFER CREDIT REQUIREMENTS

1. The formal application for all potential transfer credit students to Lowell Technological Institute must be filled out in its entirety. An affirmative answer to Question 6B is a requisite.
2. Completed application forms are considered by the Committee on Admissions. Selection of potential transfer credit students is based entirely on its determination. Successful candidates will receive Form 1 application following this decision. Students denied transfer credit will be notified by mail.
3. The prospective student, in completing this form, MUST indicate the curriculum major he intends to pursue at Lowell Technological Institute. Lowell Tech reserves the right to limit assignment of transfer students to specific curricula.
4. The transfer credit applicant should list in Column I our course title and number all Lowell Tech subjects offered comparable to those *completed* at another college or university. This enumeration should also include such comparable subject titles as are *in progress* or *in contemplation*.
5. Those subjects taken at other institutions of learning

should be listed by course title and number in Column II and matched to each one being petitioned for credit appraisal at LTI. Subjects in progress or contemplated for completion must likewise be included.

6. Credit will not be considered in subjects where the applicant's grade is lower than "C", or from an institution granting neither an associate nor bachelor's degree.

7. The third column should include catalogue page number and description of subjects taken at other recognized institutions. The fourth should include text required in the particular subject. The fifth must show the name of the institution where the applicant studied. Do not mark Column Six.

8. All completed information with the most recent transcript (s) and catalogue (s) must be received at the Lowell Technological Institute Admissions Office no later than April 1. There will be no exceptions.

9. As courses so indicated in Form 1 are completed, it is the obligation and sole responsibility of the individual applicant to supply the official transcript record to LTI. Transcripts for subjects ending after the April 1st deadline, must be received by August 1st. The college will not solicit this required information.

10. Students completing the equivalent of one full year of college work waive the SAT examination requirement. Others must forward official copies of SAT figures from Princeton, N.J.

11. One full year of physical education completed at another institution will be considered for transfer credit. This subject is a degree requirement at LTI.

Re-Admission Policies

All students desiring consideration for readmission to Lowell Technological Institute must submit pages 1 and 2 of our formal application, completed in its entirety, with a check in the amount of $10.00.

A letter giving the original date of entrance to this college and a brief resume of what has been done since leaving Lowell Technological Institute *must* accompany this application. List in this resume other schools attended, subjects taken, and grades received.

When all of these items have been received in the Admissions Office, a letter will be sent notifying the applicant of the decision of the Committee on Admissions. No notification will be given by telephone or in person. Applications received after June 1 *will not be considered under any conditions* for admission to the Institute in September of that year.

STUDENT HOUSING AND SERVICES

Residence Halls

All male students not living at home are required to live in the residence halls on campus unless excused in writing by the Dean of Students. Excuses are reviewed at the beginning of each semester and may be cancelled, should conditions warrant.

Application for permission to occupy other living quarters must be made by letter to the Office of the Dean of Students.

Permission to live at home is accorded in cases where the student lives a reasonable distance from the Institute, where financial hardship would be involved through living in a residence hall.

Dormitory rooms are furnished by the Institute and students are responsible for their care. Each student must supply his own sheets, pillow, and pillowcases, blankets, towels, and personal linens or may subscribe to the laundry service provided for all resident students at a reasonable cost. Each occupant of a room is responsible for damage to furniture, equipment, and interior surfaces.

Room assignments in residence halls are made for the full academic year. A change of room is not permitted except in rare instances and may be accomplished only after formal application for the change is approved by the Office of the Housing Officer.

Rental charge for each residence room is made for the semester. While the charge covers occupancy only during periods when the Institute is in regular session, it may, at the discretion of the Dean of Students be extended to include vacation periods.

Room assignments are made as equitably as possible and in the order that applications are received. The Housing Officer supplies a list of rooming houses where students may reside who are unable to be placed in residence halls.

Students are cautioned to make no legal agreements nor sign residence leases with persons outside the Institute.

Students living in Residence Halls are forbidden to keep pets, intoxicating beverages, narcotics, firearms, ammunition, explosives or fireworks in the building or on campus.

Detailed regulations covering such things as noted in the above paragraph are contained in the L.T.I. Handbook — THE KEY.

Dining Hall

A cafeteria and a snack bar are available in the residence halls, but use of campus dining facilities is not compulsory.

Health Service

The dispensary is in the charge of two registered nurses for

eight hours each school day. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to take in case of illness. Medical services are available to students 24 hours daily. There are three excellent modern hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

If a student requires emergency surgical treatment, every effort is made to communicate with a parent or guardian. Failing this, such action is taken as appears to be necessary in the interest of the student.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance also is available, on a voluntary basis, through the Office of the Dean of Students.

Guidance

The guidance program, under the supervision of the Dean of Students Office, starts with the admissions procedure and continues throughout the freshman year. During Orientation Week, the freshman attends a series of lectures the purpose of which is to help in the adjustment to college requirements.

Freshmen should contact instructors for academic problems and, if necessary, a referral may be made to the Dean of Freshmen for further assistance. Personal difficulties such as financial or similar problems should be brought directly to the Dean of Freshmen. Due to the large numbers of students each year, it is impossible to call in all students. Responsibility for interviews must rest with the student who needs advice or clarification.

Other phases of the guidance program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions. In the second semester of the freshman year a series of lectures is offered to help the student become aware of the curricula at the Institute and determine what course he should elect for the next three years.

Guidance in the upper classes is generally conducted in scholastic matters by the Head of the department concerned and in personal problems by the Dean of Students.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A STUDENT MAY BE DROPPED FROM THE ROLLS WHENEVER IT IS CONSIDERED IN THE BEST INTERESTS OF THE INSTITUTE.

In some laboratories students are required by state law to wear safety eyeglasses, which may be purchased at the LTI Bookstore. The instructor in each class requiring the use of such eyeglasses will inform the students of the necessity of using them.

Disciplinary Action

The privileges of the Institute may be withdrawn from any student at any time if such action is deemed advisable. It should be understood that the Institute acting through the Board of Trustees or any administrative officer designated by them distinctly reserves the right, not only to suspend or dismiss students, but also to name conditions under which they may remain at the Institute. Notation of disciplinary action is made a part of the permanent record of the student.

Attendance

All students must attend all classes, although a limited number of absences is permitted. One absence is allowed for the number of weekly class meetings, except for laboratories.

Academic Grades

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.30	(97-100)	C+	2.30	(77-79)
A	4.00	(93-96)	C	2.00	(73-76)
A−	3.70	(90-92)	C−	1.70	(70-72)
B+	3.30	(87-89)	D+	1.30	(67-69)
B	3.00	(83-86)	D	1.00	(63-66)
B−	2.70	(80-82)	D−	0.70	(60-62)

F 0 (below 60)

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester is obtained in the same manner as the computation for the rating of a single semester.

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

In order that a student be classified "clear", he must achieve the following minimum semester ratings:

first-semester sophomore	1.45
second-semester sophomore	1.50
first-semester junior	1.55
second-semester junior	1.60

A student must achieve the following cumulative ratings:

beginning of sophomore year	1.40
beginning of junior year	1.50
beginning of senior year	1.60

Probation and Dismissal

A student is placed on probation when his semester rating is below 1.35. A student who fails to achieve the required cumulative rating shall be placed on probation. The probationary period covers the entire semester following the issuance of the semester or cumulative rating which placed the student on probation.

A student on probation may not represent the Institute in any public function or any extracurricular activity and may not hold any class office or other office during his term of probation. If a student receives a semester rating below 0.70, he is automatically dropped from the Institute without benefit of a probationary period. A student with a semester rating of less than 1.35 for two consecutive semesters is dropped from the Institute for at least one semester. If a student is dropped for either of the last two reasons, he MUST take subjects at some other college to prove himself before applying for readmission to LTI. These subjects are non-transferable, but rather prove the student's capability academically.

A student on academic probation will be dropped from the Institute for at least one semester if during his probationary semester he fails to achieve the required semester rating.

Requirements for Graduation

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in a major subject.
2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors—graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors—graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors—graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION FEE.................................. $10

1. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days of the date upon which the applicant is accepted for admission. For Massachusetts residents this amounts to $50. This prepayment is forfeited if the student fails to register at the Institute. In rare instances, such as sickness which would prevent the applicant from enrolling, this rule may be waived by the Dean of Students.
2. The application fee is NOT credited to the student's tuition.

TUITION

(per year)

U. S. citizens who are residents of Massachusetts....**$200**

All others...**$600**

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

U. S. citizens who are residents of Mass..**$10.00 per cr. hr.**

All others............................ **$30.00 per cr. hr.**

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.
2. The residence of a minor follows that of the parents,

unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evidence of emancipation.

3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.
4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.
5. The residence of a wife follows that of the husband.
6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.
7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.
8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

ROTC DEPOSIT **$25**

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the amount on deposit, he must pay the charges and make an additional deposit of $25.

ACTIVITY AND INSURANCE FUND **$49**

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

RESIDENCE HALLS

The residence hall charge is $350 per student per year. Each student will be billed for the room for the entire academic year. In the event a student is dropped at any time during the year he is still responsible for the room charge and will be reimbursed only if the room is rented to another student.

LATE REGISTRATION FEE $25

A student who does not complete his registration (including the payment of all fees) by the close of the registration period must pay this additional fee.

AUDITING FEE ....$5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay $5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE $15

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

FRESHMAN DUES $5

All students classified as freshmen must pay this fee when they are billed.

OFFICIAL TRANSCRIPT FEE $1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of $1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

Laboratory equipment may not be removed from the premises except by special permission.

TUITION REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks At least	But less than	Refund Rate
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over		None

SUMMARY OF EXPENSES PER YEAR

Tuition

U. S. citizens who are residents of Massachusetts.... **$200**

All others.. **$600**

Residence halls .... **$350 per student per year**

Student activity and insurance fee.................... **$ 49**

ROTC deposit.................................... **$ 25**

Books, supplies, and related miscellaneous

expenses (approximate)........................... **$100**

There is no set boarding fee, but a cafeteria is available for meals on a cash basis.

FINANCIAL AID

At L.T.I. financial aid is available to full time students in good standing who are citizens of the United States, during the Fall and Spring and Summer Session. Aid to a student may be in the form of a National Defense Student Loan, a Federal Grant, part time employment in the Federal College Work-Study Program, a scholarship, or any combination of these financial aids to continue their education. Each program is designed to meet the particular need of the student and the applicant is required to complete the required forms regarding parental income and assets since this will be the basis for determining the amount and type of aid granted.

A Parents Confidential Statement must be sent to the Institute by all candidates, through the College Scholarship Service, Princeton, New Jersey.

Students may obtain applications and information regarding these programs at the Financial Aid Office, O 112.

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time. At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Director of Admissions before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Albany Felt Company Scholarship

One annual grant of $500 to a freshman entering the Institute is

made by the Albany Felt Company. Each recipient is given an opportunity for summer employment at the company while in college.

Alumni Association Scholarships
The LTI Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from the following sources:
Stephen E. Smith Scholastic Fund
James T. Smith Fund
Arthur A. Stewart Memorial Scholarship Fund
Warwick Chemical Foundation in memory of Walter Nowicki
New York Chapter, LTI Alumni Association

Berkshire Hathaway, Inc. Scholarships
A number of scholarships covering tuition and living expenses for four years are offered in Textile Engineering and Textile Technology by Berkshire Hathaway, Inc., Providence, R. I. Male employees and sons of employees only are eligible. Students interested should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence, R. I.

Russell L. Brown Scholarship, donated by

Davis and Furber Machine Company
This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipend is $300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship
This $200 scholarship is awarded to the male student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship
This $250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships
The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is $200, and each is renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of $250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and financial need and the scholarships are renewable on the condition that satisfactory grades are maintained.

Paper Engineering Department Scholarships

Five scholarships, each amounting to $2000 over the four-year period, are available to incoming freshmen who plan to enroll in the Paper Engineering program. Scholarship holders receive annual stipends of $500 provided they maintain good academic standing.

Present contributors to this scholarship program include the following:

Bryon Weston—Crane and Company
Carter, Rice, Storrs & Bennett, Inc.
Crocker, Burbank & Co., Association
Dennison Manufacturing Company
Erving Paper Mills
Fraser Paper Ltd.
Hollingsworth & Vose
International Paper Company
Ludlow Corporation
Mohawk Paper Mills
Nashua Corporation
Oxford Paper Company
Paper Management Association,
  Connecticut Valley Division
Riegel Paper Corporation
Tileston & Hollingsworth Company
Triangle Foundation
S. D. Warren Company

Sylvan I. Stroock Scholarship, donated by S. Stroock & Co., Inc.

A $500 scholarship is awarded each year on the basis of scholarship, financial need, leadership, and promise of success in textile fields from funds established by S. Stroock & Co., Inc.

Science Count-Down Scholarship

A one-year tuition scholarship is available annually to a student who has won first place in Science Count-down, the televised science quiz for Massachusetts eighth-grade pupils, co-sponsored by the Institute and WBZ-TV, the Westinghouse Broadcasting Company television station in Boston.

United Elastic Corporation Scholarships

Scholarships of $250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Mass., West Haven, Conn.; and Stuart, Va.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

AVAILABLE TO UPPERCLASSMEN ONLY

AFROTC Financial Assistance Program

Financial Grants are provided on a competitive basis to a limited number of selected cadets entering Aerospace Studies 200 - 300 - 400 in the Air Force ROTC four year program. The grant covers full tuition costs, books, laboratory expenses and incidental fees. A grant earned as a sophomore or junior continues until graduation as long as the cadet maintains acceptable standards. Cadets also receive $50 per month subsistence allowance as do other cadets in the Professional Officer Course.

Allied Chemical Foundation Scholarships

Two grants of $750, given by the Allied Chemical Corporation, are awarded to worthy students majoring in Textile Chemistry or Textile Engineering.

A.S.T.M.E. Awards

Merrimack Valley Chapter 113, American Society of Tool and Manufacturing Engineers, awards $100 annually to a junior-class member in good standing of the Student Chapter on

the basis of leadership, scholarship, need, and contribution to the Society. The A.S.T.M.E. Student Chapter presents the Prof. J. Arthur Ainsworth award of up to $100 annually to any chapter member in good standing on the same terms.

Boston Paper Trade Association Scholarships

Three scholarships, each for $150, are open to sophomores, juniors, and seniors enrolled in Paper Engineering who are residents of New England. Awards are based on scholarship and character.

The Chemical Club of New England Scholarship

This scholarship in the amount of $400 is awarded to a student in Chemical Engineering or Chemistry who is a resident of New England. Selection if based on ability and financial aid.

Chemstrand Corporation Scholarship

A scholarship of $500 is available to a superior, deserving student enrolled in textiles. Donor is the Chemstrand Corporation.

DeBell-Richardson Scholarship

DeBell-Richardson, Inc., the D. & R. Pilot Plants, Inc., and John M. DeBell have established a scholarship for a student majoring in Plastics Technology. It is awarded on the basis of scholastic success, extracurricular activities, and financial need.

Dixie Cup Scholarship

The Dixie Cup Division of American Can Company of Easton Pa., has established a scholarship in the amount of $500 per year. Students majoring in Chemical Engineering, Electrical Engineering, Mechanical Engineering, Paper Engineering, or Plastics Technology are eligible to apply, and selection is based on scholastic achievement, financial need, and extracurricular participation. The Company provides summer employment for the student holding the scholarship.

Foster Grant Scholarship

The Foster Grant Company, Inc. of Leominster, Mass., makes available on a one-year basis a tuition scholarship to a deserving student in Plastics Technology who is a resident of Massachusetts. Preference is given to a sophomore living in the Leominster area; however, if there are no applicants from that area, another candidate may be chosen. Scholarship, personality, and over-all student contribution to extracurricular activities are the general criteria used in selecting the recipient.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of $75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review

the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

New England Paper Merchants Association Scholarship

A $100 scholarship is open to a sophomore, junior, or senior in Paper Engineering who is a resident of New England. It is awarded on the basis of scholarship and character.

NOPCO Chemical Company Scholarship

The NOPCO Chemical Company of Newark, N. J., has established two $250 scholarships open to students majoring in Chemical Engineering, Chemistry, Paper Engineering, Plastics Technology, or Textile Chemistry who have proved themselves scholastically and who are active in extracurricular programs.

Society of Plastics Engineers Scholarship

A scholarship is granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to an upperclassman majoring in Plastics Technology.

Uniroyal Incorporated

This Foundation has established scholarships for students who have successfully completed at least two years of college in which they have demonstrated leadership, capacity for higher education, and a recognition of its cultural and economic value. Applicants must be in need of financial assistance, and recipients assume a moral obligation to repay over a reasonable period at least 25% of the scholarship aid received.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, not to exceed $800, is available to an under-graduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes, scholarships are awarded annually and are renewable under the usual conditions. The scholarships cover tuition and books. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and leadership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

Russell Weeks Hook Scholarships

Six undergraduate scholarships for needy, qualified students in Chemistry or Textile Chemistry in the amounts of

$225 are awarded each year, two awarded to each of the upperclasses.

AVAILABLE TO GRADUATE STUDENTS ONLY

Fellowships for graduate students are listed and described in the Graduate School section of this catalogue.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of $10 per quarter the first year and $20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry or Paper Engineering. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

FEDERAL FINANCIAL AID PROGRAMS

Available to Undergraduate & Graduate Students.

National Defense Student Loan

The National Defense Education Act offers loans to needy students. Repayment begins one year after graduation, unless military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3%, beginning with the first payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

College Work-Study Program

The Economic Opportunity Act of 1964 (P.L. 88-452) as

amended by Economic Opportunity Act of 1965 (P.L. 89-253) and the Higher Education Act of 1965 (P.L. 89-329) Title I Part C established the College Work-Study Program to stimulate and promote the part time employment of students, particularly students from low income families who are in need of the earnings from such employment to pursue courses of study in institutions of higher education. At LTI the program is available to full time students in good standing at the undergraduate and graduate levels during the Fall and Spring semesters and during the Summer Session.

Educational Opportunity Grants

The Higher Education Act of 1965, Title IV, Part A (P.L. 89-329) affirms the policy of the United States to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in post-secondary and higher education. The Act initiates a program of educational opportunity grants through institutions of higher education, to assist in making available the benefits of higher education to qualified high school graduates of exceptional financial need, who for lack of financial means of their own, or of their families, would be unable to obtain such benefits without such aid.

AWARDS

AVAILABLE TO UNDERGRADUATE STUDENTS ONLY

American Association of Textile Chemists and Colorists Book Prize. This is awarded to the outstanding graduating senior in the Textile Chemistry course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemistry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

ASTME Award. The Merrimack Valley Chapter, American Society of Tool and Manufacturing Engineers awards $100 to a

member of the Student Chapter of the ASTME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years at college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Ben Faneuil Award. An annual award of $100 is made by Mr. Ben Faneuil of The Chelsea Industries, Chelsea, Massachusetts, to the sophomore majoring in Plastics Technology with the highest cumulative average.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of $50 in memory of Professor Jacob K. Frederick to a freshman, based on scholastic achievement and extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of $250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, formerly of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of $100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering

selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry or Textile Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in Chemistry.

President's Medal. This award is made to the student who is graduated With Highest Honors for the most distinguished academic record in his class.

The Harry Riemer Honor Award. This award is made available through the Textile Veterans Association of New York in honor of Mr. Harry Riemer, one of the textile industry's foremost personalities in the trade publication field. The award, which consists of a $25 United States Savings Bond, is made to an outstanding textile graduate who has been active in extracurricular activities and who has maintained a high level of scholastic achievement.

Radio Station WLTI Award. The staff of the student-operated radio station WLTI awards a plaque annually to a member outstanding for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

OTHER ASSISTANCE FOR MASSACHUSETTS Residents only

Board of Educational Assistance Scholarships

These scholarships for one-quarter, one-half, or full tuition are available both to freshmen and to upper classmen. For full information write to:

Executive Secretary
Board of Educational Assistance
200 Newbury Street
Boston 16, Mass.

Massachusetts Higher Education Loan Plan (H.E.L.P.)

This plan enables the Massachusetts commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, to make available unsecured student loans. Students must be accepted by or enrolled in an institution furnishing a program of higher education which is approved by a State or Federal approving agency and by the Massachusetts Higher Education Assistance Corporation. A student who is a permanent resident of the United States may borrow up to $1,000 a year for undergraduate school, or $1,500 a year for graduate school. There is no interest charge on such loans while the student is in school, provided parental adjusted income is under $15,000. Upon leaving school there is a charge of 3% per year on the unpaid loan balance. Monthly repayment of the loan begins within one year after graduation. Loan applications are available at commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, in the town of the student's residence.

Specific inquiries regarding this program should be addressed to:

Massachusetts Higher Education Assistance Corporation
511 Statler Building
Boston, Massachusetts 02116
Telephone 426-9434

Cooperative Study Program

The First Naval District has approved Lowell Technological Institute as Sponsor of its Cooperative Work-study Program at the Boston and Portsmouth Naval Shipyards.

Students will undertake a five-year program in their field of specialization - electrical, electronic, chemical, civil and mechanical engineering, increasing their experience and capabilities in subsequent on-the-job training at either shipyard. Successful students will earn the bachelor of science degree.

Information concerning this program may be obtained by

writing the First Naval District Headquarters at Charlestown or the Director of Admissions, Lowell Technological Institute.

PLACEMENT

Industrial Training Program

The Placement Office maintains two basic functions. One is to counsel the senior planning to take recruiting interviews; the other is arranging the dates of interviews for the representatives of the recruiting companies and agencies.

In the counselling process the Placement Officer reviews the student's transcript with him, discussing his points of strength and weakness. The elements of the recruiting procedure are explained so that he may be properly prepared for the ensuing interviews.

Approximately one hundred and eighty companies and government agencies recruit on the LTI campus. The companies represent a cross-section of industry in the country ranging from the so-called giants down to those of relatively small size. Geographically, they are located in the Northeast, the Southeast and the Mid-West with a few from the Far West. Thus, the seniors get fairly broad exposure to business opportunities.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Memorial Library, the Research Foundation, and the Summer School program, the college provides such special services to industry and to the community as the following:

Industrial seminars and conferences;
Guidance work in the high schools;
Technorama, science fair for area high schools;
Consultive opportunities with the faculty;
Collaboration with the Agency for International Development of the government in its foreign aid program;
Special radio and television programs, such as Science Count-Down on Boston station WBZ-TV.

For information relative to these programs, address the Coordinator of Special Services at the Institute.

SUMMER SESSION

The Summer Session is designed primarily to serve three principal areas of interest: Professional Advancement Courses for industrial personnel; Undergraduate Credit Courses for college students who require deficiency clearance or who seek advanced standing; and Precollege Refresher Courses for incoming freshmen at LTI.

The industry-sponsored professional advancement program comprises a series of specialized intensive, one-to three-week courses in leather, paper, and textiles. The two six-week under-graduate sessions stress fundamental credit offerings in college mathematics, physics, chemistry, English, economics, electronics, mechanical engineering, accounting, marketing, management, and social studies.

Precollege Refresher Courses

The Precollege Refresher Program is especially designed for prospective LTI students who require additional background to fulfill minimum entrance requirements. Students must first apply for fall admission; the Director of Admissions designates the course or courses required for coverage of minor deficiencies in the high'school background. Five-week, noncredit courses in basic mathematics, physics, chemistry, and English are offered in June session to accommodate all freshman candidates.

For further information or a Summer Session Bulletin, write to the Director of Summer School.

DIVISION OF EVENING STUDIES

The Division of Evening Studies offers five-year associate degree courses in business management, chemistry, mathematics, and radiological health, and in the following technologies: electrical engineering, electronic engineering, industrial engineering, industrial engineering, mechanical engineering, and plastics engineering.

It also offers a program of individual subjects in mathematics, science, technology, engineering, and general studies. These subjects are designed to serve the needs of the community, particularly of those people engaged in industry who wish to further their education.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Division of Evening Studies also offers an In-Service Training Program in Civil Engineering Technology limited to employees of the Commonwealth of Massachusetts and to employees of cities and towns within the Commonwealth.

The Graduate School offers a program in the Division of Evening Studies which leads to the Master of Science degree on a part-time basis. The academic requirements for this program are identical with those of the day school. Graduate courses offered in the day or evening programs are interchangeable.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. Selected subjects are also offered in an 8-week summer program. For further information, write to the Director of the Evening School.

RESEARCH FOUNDATION

The Lowell Technological Institute Research Foundation is a nonprofit organization authorized under the laws of the Commonwealth of Massachusetts. It was established for the purpose of encouraging and administering research sponsored by industry and government at the Lowell Technological Institute.

Its research projects benefit the educational program of the Institute by enabling both faculty and students to keep abreast of current developments in their respective fields and to develop further their capabilities.

The scientists and engineers of the Foundation's permanent personnel, together with the faculty of the Institute, constitute a staff available for research, development, and testing in the fields of chemistry, electronics, engineering, leather, management, paper, plastics, and physics.

The Research Foundation has its own specialized laboratories and field stations where research ranging from chemical modification of textile fibers to studies of the ionosphere and

thermal radiation is performed. The Foundation also uses in its programs the entire facilities of the Institute. These facilities not only include the usual research tools found in a university or industrial laboratory but also include, in the areas of leather, paper, plastics, and textiles, full-scale and pilot-plant equipment for specialized studies. It is probably the only research organization in the world having at its disposal fully equipped laboratories for processing all types of fibers by all the common manufacturing systems into a finished fabric.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, publishes the official alumni newsletter, and the alumni directory, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum and Evening Division senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of Directors to any person not an active member who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts of sciences.

Communications should be addressed to the Executive Secretary, Alumni Office, Lowell Technological Institute.

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four officers elected by the student body, the president of each undergraduate class, and one representative from each of the classes. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee.

Alpine Club

Composed of students interested in mountain climbing, skiing, and associated sports. Numerous weekend trips are scheduled throughout the year. Highlight of the club is the week-long skiing trip during the semester break.

Angel Flight

Angel Flight is the co-ed auxiliary to and is sponsored by the Vandenberg Air Squadron of the Arnold Air Society. It is primarily a service organization. Its objectives are to advance and promote interest in the Air Force, obtain information regarding military services, and aid the progress of the Arnold Air Society at the Institute.

Athletics

The Athletic Association promotes an extensive varsity and intramural sports program. Varsity sports are soccer, basketball, baseball, skiing, tennis, and golf, and competition is mainly with college teams in the northeast section of the country. Intramural sports competition among classes, residence hall students, and fraternities is carried on throughout the year. All students are members of the Association and receive free admission to all intercollegiate contests played at home.

Audio-Visual Society and Radio Station WLTI

The Audio-Visual Society was formed on the campus in the academic year 1959-1960 for the purpose of providing film and musical programs for the students and faculty of L.T.I. The constitution was redrawn in the fall of 1963 to include carrier current radio station WLTI (650 kc.) as the Broadcasting Services Branch, and incorporated a Technical Services Branch in addition to the original Audio-Visual Services Branch.

The new library addition under construction will have extensive audio-visual facilities including offices, workshops, master control, individual and group listening rooms, a multi-purpose room and radio studios.

WLTI was originally organized as The Lowell Tech Broadcasting Society, and first went on the air in 1953. In 1965, a giant step toward the dream of an educational FM station was realized with the gift of a 10 Kw FM transmitter. Work is now under way on the renovation of this equipment and the licensing of the station. Both stations will have new studios and quarters on the ground floor of the library. Operation of these facilities will require the efforts of a skilled engineering staff. Programming, announcing, advertising and publicity will call for a large student staff.

The Technical Services Branch was added to A.V.S. in 1963 for the purpose of maintaining and repairing the technical equipment used by the society. This department also has the responsibility of designing and modifying all new equipment, and offers an interesting challenge to technically minded students.

Many openings are available in the Society for the student interested in enhancing his education while serving the institute. Also important is the opportunity to work with fellow students and faculty members. Membership is open at all times; interest is the only prerequisite.

Band

Band membership is open to all students who possess musical training or wish to learn to play a band instrument.

Bowling Club

During the past three years, L.T.I. has had bowling teams in Intercollegiate competition with most of the members coming from the bowling league. The rest of the teams are made up of veteran non-league bowlers and others discovered through tryouts.

In three years of intercollegiate competition, L.T.I.'s teams have been at the top of the College bowling bracket. Under the direction of L.T.I. Librarian Joseph V. Kopycinski, they have won over 100 trophies and hold every title at least once at all of the major N. E. College tournaments. In 1966, a Lowell Tech bowler represented the New England area at the National ABC Tournament, in Rochester, N. Y.

In 1967, L.T.I. was one of the founders of the Tri-State College Bowling Conference which is rapidly expanding and consists of seven teams in the men's division and three in the girls' division.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Chinese Students Circle

The aims of this organization are to render assistance to newly arrived Chinese students at L.T.I., to promote and interpret on campus the culture and life of China, to encourage members to participate more fully in the extra-curricular activities on campus and in the Boston area, and to share common interests and develop understanding and social contact among the Chinese students at the Institute.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshmen.

Dormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

Duplicate Bridge League

Open to students and faculty members, the league conducts ten or more playing sessions each year to determine the champion team. Student members also participate in the annual national Intercollegiate Duplicate Bridge Tournament.

Eta Kappa Nu

To be eligible for membership in this scholastic honor society, one must be an Electrical Engineering major who has participated in campus activities and is of exemplary character. Juniors must be in the upper quarter of their class, and seniors must be in the upper third of their class. The purpose of the organization is to provide a closer union for students majoring in Electrical Engineering who have achieved high scholastic standing, demonstrated leadership in campus activities, and possess outstanding character.

Fraternities

There are five fraternities—Delta Kappa Phi, Omicron Pi, Phi Gamma Psi, Pi Lambda Phi, and Sigma Phi Omicron—all of which have their own houses. All provide social life off campus and two are national fraternity affiliates. The Inter-fraternity Council fosters the common interests of the five and sponsors interfraternity social and athletic events.

Graduate Club

An organization to promote interdisciplinary understanding and provide a social program for Graduate students and Graduate faculty of LTI.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Judo Club

The purpose of this organization is to provide instruction in Judo for those interested in this program.

Karate Club

Instruction in Karate is made available to members of this organization.

Lacrosse Club

Lacrosse is one of the fastest growing sports in the United States. The object of this organization is to provide student members with a means of participation in athletic competition in Lacrosse with the ultimate purpose of the establishment of Lacrosse as a varsity sport.

Latin-American Society

This organization unites students of Latin-American origin in a cultural and social program.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the military profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units.

Pickout

The Pickout is the college yearbook. Its staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students

and guest speakers present technical papers and lectures:

- American Association for Textile Technology, Student Chapter
- American Chemical Society, Student Chapter
- American Institute of Physics, Student Section
- American Nuclear Society, Student Chapter
- American Society of Mechanical Engineers, Student Chapter
- American Society of Tool and Manufacturing Engineers, Student Chapter
- Chemical Engineering Society
- Industrial Management Society
- Institute of Electrical and Electronics Engineers, Student Chapter
- MALTI (Mathematics Association of LTI)
- Paper Engineering Society
- Society for Advancement of Management, Student Chapter
- Society of Plastics Engineers, Student Chapter

Religious Groups

Christian Science Organization

The purpose of the Christian Science Organization is to provide for all interested students the opportunity to learn of Christian Science and its application to student life. Activities of the organization include weekly meetings, an organization-sponsored lecture, and informal meetings with Christian Scientists from other colleges.

Hillel.

The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship

Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Club

Through the combined efforts of the spiritual advisors and many local friends, the Newman Club now has a Newman Center located at 52 Colonial Avenue (in the immediate vicinity of the campus). A student lounge with a library for study and a rumpus room with piano and Hi Fi system are available for student recreation. The center is open to all students of LTI,

Lowell State College, and Lowell General Hospital School of Nursing from 10:00 a.m. to 1:00 a.m., Monday through Friday. Discussion groups and meetings with the Chaplains are in progress weekly, and all students are urged to visit and participate in the many programs now offered at the Newman Center.

Phanar Club

This is composed of Greek Orthodox students from Lowell State College and LTI.

Rifle and Pistol Club

Membership in the Rifle and Pistol Club is open to all students and faculty at LTI. The purpose of this organization is to promote and facilitate the shooting sports among members.

Rowing Club

The LTI Rowing Club introduces LTI students to the techniques, training, and physical fitness required for competitive crew. Full fall and spring schedules provide races against schools, clubs, and colleges under the auspices of both The National Association of Amateur Oarsmen and The New England Amateur Rowing Association. Full coaching is provided for newcomers to the sport.

Skindiving Club

Non-divers are taught the safety measures involved by experienced divers who also skindive as a group.

Sorority

Phi Sigma Rho, the campus sorority, provides a center for the social life and association of the young women enrolled at the Institute.

Sports Car Club

This club promotes the safe, courteous, efficient, and skillful operation of sports cars on the highway and is a source of information for members.

Student Wives Club

The purpose of this organization is to provide a common meeting ground for students' wives, to share the problems unique to students' wives, to assist newcomers to the Lowell area, to promote friendship and to provide "low budget" entertainment for married couples on campus.

Squash Club

Three regulation singles courts are available for this sport at the gym and the Physical Education Staff instructs new members and conducts clinics for seasoned players.

Swim Club

This club operates under faculty supervision.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

TOC

The Tech Orientation Committee has as its special function the introduction of the new student to college life. TOC plans a month-long series of activities for entering freshmen during the orientation period to enable them to meet one another and to realize their responsibilities to their college.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students. The bi-monthly publication offers excellent journalistic and business experience to those who work on its staff.

Vandenberg Air Squadron of the Arnold Air Society.

The Vandenberg Air Squadron, a chapter of the national Arnold Air Society, unites selected Professional Officer Course AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs and aerospace exhibits during the year. The Military Weekend, annual highlight of its program, is climaxed by the formal Military Ball at which time new members are accepted into the society.

Varsity Club

The Varsity Club is composed of students who have earned letters in the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose is to give academic help to athletes and to foster a lasting friendship among the men participating in athletics.

UNDERGRADUATE PROGRAMS

Fifteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science except the Business Administration program which leads to the Bachelor of Business Administration degree. These fields are:

- Business Administration
- Chemical Engineering
- Chemistry
- Civil Engineering
- Electrical Engineering
- Industrial Management
- Mathematics
- Mechanical Engineering
- Meteorology
- Nuclear Engineering
- Paper Engineering
- Physics
- Plastics Technology
- Textile Engineering
- Textile Technology

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute and students.

Four-year curricula leading to the degree of Bachelor of Science in Engineering Technology are in the process of being developed in most of the above fields of engineering. They should be ready for admission of students within the next two years.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

An asterisk following a subject number, e.g., PH 411*, indicates a subject which, although is primarily for undergraduates, may, under certain circumstances, be taken for full graduate credit.

THE ELECTIVE SYSTEM

In all curricula and opportunity is afforded the student to elect subjects in addition to those required for graduation. These fall into two categories: Technical Electives and General Electives.

Technical Electives give the student a chance to broaden his professional knowledge by taking courses allied to his field of concentration or to further his knowledge of a particular phase by additional work therein.

General Electives are to be selected from the following list of subjects. At least two electives must be chosen in the social sciences (SS) and two in languages and literature (LL). The total number of such electives must meet the requirements of the particular curriculum being pursued.

Subjects required in the Air Force ROTC program in the sophomore year are in addition to all other subiects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects required in the junior and senior years in the ROTC program may be substituted for General Electives in all curricula unless otherwise specified.

EC 201	Economics I	(3-0)3
EC 202	Economics II	(3-0)3
EC 301	Economic Development of The U. S.	(3-0)3
EC 304	Macroeconomic Theory	(3-0)3
EC 402	Government and Business	(3-0)3
EC 404	Comparative Economic Systems	(3-0)3
EC 408	History of Economic Thought	(3-0)3
EC 410	Economic Development of Less Developed Countries	(3-0)3
EC 412	Managerial Economics	(3-0)3
EC 414	Engineering Economy	(3-0)3
LL 209	Technical and Scientific Communication	(3-0)3
LL 213	Introduction to English Literature: To 1798	(3-0)3
LL 214	Introduction to American Literature: From 1865	(3-0)3
LL 215	Introduction to American Literature: To 1865	(3-0)3
LL 216	Introduction to English Literature: From 1798	(3-0)3
LL 233	Comparative Literature	(3-0)3
LL 234 or 235	Shakespeare	(3-0)3
LL 259-260	Elementary German	(3-0) (3-0)6
*LL 261-262	Elementary Scientific German	(3-0) (3-0)6
LL 263-264	Elementary French	(3-0) (3-06

*LL 265-266	Elementary Russian	(3-0) (3-0)6
LL 267-268	Elementary Spanish	(3-0) (3-0)6
LL 269-270	Elementary Modern Greek	(3-0) (3-0)6
LL 311	Advanced Composition	(3-0)3
LL 313	Introduction to Continental Literature	(3-0)3
LL 314	Continental Literature Since the Renaissance	(3-0)3
LL 316	The English Bible as Literature	(3-0)3
LL 333 or 334	Problems of Philosophy	(3-0)3
LL 341 or 342	Satire	(3-0)3
LL 344	Modern Poetry	(3-0)3
LL 345	Modern Irish Literature	(3-0)3
LL 363-364	Intermediate French	(3-0) (3-0)6
*LL 365-366	Intermediate Literary and Conversational Russian	(3-0) (3-0)6
LL 367-368	Intermediate German	(3-0) (3-0)6
LL 369-370	Intermediate Spanish	(3-0) (3-0)6
LL 435	English Literature of the Eighteenth Century	(3-0)3
LL 436	English Romantic Poets	(3-0)3
LL 437	English Literature of the Victorian Period	(3-0)
LL 467 or 468	Seminar in German Masterpieces	(3-0)3
LL 471	The Modern American Novel	(3-0)3
LL 472	The Modern British Novel	(3-0)3
LL 473	World Drama	(3-0)3
LL 474	Modern Drama	(3-0)3
LL 476	Nineteenth Century British Novel	(3-0)3
LL 482	The American Short Story	(3-0)3
LL 495 or 496	Reading and Research	(3-0)3
SS 223	The United States: 1865 - 1912	(3-0)3
SS 224	The United States: 1912 to the Present	(3-0)3
SS 225	Europe: 1789 - 1914	(3-0)3
SS 227	Europe: 1914 - 1939	(3-0)3
SS 228	Europe: 1939 to the Present	(3-0)3
SS 301	Government of the United States	(3-0)3
SS 302	Conduct and Control of Foreign Policy	(3-0)3
SS 303 or 304	Psychology	(3-0)3
SS 305 or 306	Sociology	(3-0)3
SS 371 or 372	American Civilization to 1865	(3-0)3
SS 471	The United States in World Politics	(3-0)3
SS 472	Defense Policy	(3-0)3
SS 477	Russia: The Empire	(3-0)3
SS 478	Russia: The Soviet Union	(3-0)3
SS 479	The Far East Since 1842	(3-0)3
SS 480	Modern China: 1644 to the Present	(3-0)3
SS 481 or 482	The Greeks and Western Civilization	(3-0)3

SS 483	Political and Social Thought: The Greeks and the Romans	(3-0)3
SS 484	Political and Social Thought: 400 - 1600 A.D.	(3-0)3
SS 485	Political and Social Thought: 1600 - 1800	(3-0)3
SS 486	Political and Social Thought: 1800 to the Present	(3-0)3
SS 487	American Political Thought to 1865	(3-0)3
SS 488	American Political Thought Since 1865	(3-03
SS 492	Twentieth Century Germany	(3-0)3
SS 495	The Technological Future: The Material Aspects	(3-0)3
SS 496	The Technological Future: The Political and Social Aspects	(3-0)3
SS 499	Science and Religion: Science as a Social System	(3-0)3
SS 500	Science and Religion: Religion as a Social System	(3-0)3

* These subjects are not accepted for credit, *except as an overload,* in Chemistry, Chemical Engineering, Electrical Engineering, Mechanical Engineering, Paper Engineering, and Textile Engineering.

THE AIR FORCE ROTC PROGRAM

The Board of Trustees has directed that, effective September, 1968, all able-bodied nonveteran male U.S. citizens must satisfactorily complete the Air Force ROTC program throughout the entire freshman year.

The program is designed to qualify for commissions those men who desire to serve in the United States Air Force, and to provide an education that will develop skills and attitudes vital to professional Air Force Officers.

The Air Force ROTC program is divided into two phases: the General Military Course (GMC) the first two college years and the Professional Officer Course (POC), the last two years.

A student may elect to enroll in the Two-Year AFROTC Program or the Four-Year AFROTC Program. A student electing the Four-Year Program will take the General Military Course during his freshman and sophomore years and the Professional Officer Course during his junior and senior years. He will attend four weeks of field training during the summer between his junior and senior years. As a member of the four-year program he is eligible to compete for the equivalent of a scholarship through the Financial Assistance Program. For acceptance into the POC the Four-Year Program student must pass a physical examination and an Officer Qualification Test. To qualify for enrollment in the Two-Year Program, a student must have two academic years remaining at either the graduate or undergraduate level or a combination of the two. He must also meet certain physical standards and pass an Officer Qualification Examination. Further, he must successfully complete a six weeks Field Training Course before he can be accepted into the Professional Officer Course. Students in the Two-Year Program are not eligible to compete for the AFROTC Financial Assistance Program. Transfer students may elect the Professional Officer Course by satisfying the above requirements.

Uniforms and all equipment and textbooks required for AFROTC work are supplied by the United States Air Force. Students in the Professional Officer Course receive a $50.00 a month retainer fee. Additional financial assistance is available to a limited number of cadets in the four-year program on a competitive basis.

Students who successfully complete the Professional Officer Course are commissioned as second lieutenants in the United States Air Force Reserve. Those who qualify may receive further training after commissioning in scientific skills, pilot or navigator training, or administration. Outstanding seniors who are designated Distinguished AFROTC Cadets may apply for regular commissions and postgraduate education assignments.

GENERAL MILITARY COURSE

FRESHMAN YEAR

First Semester

AS 101	World Military Systems I	(1-1) 1

Second Semester

AS 102	World Military Systems II	(1-1) 1

SOPHOMORE YEAR

First Semester

AS 201	World Military Systems III	(1-1) 1

Second Semester

AS 202	World Military Systems IV	(1-1) 1

PROFESSIONAL OFFICER COURSE

JUNIOR YEAR

First Semester

AS 301	Growth and Development of Aerospace Power I	(3-1) 3

Second Semester

AS 302	Growth and Development of Aerospace Power II	(3-1) 3

SENIOR YEAR

First Semester

AS 401	The Professional Officer I	(3-1) 3

Second Semester

AS 402	The Professional Officer II	(3-1) 3

Subjects required in the AFROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects required in the AFROTC program in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

CORPS TRAINING

Corps Training is conducted one hour each week. This is an assembly of the entire cadet corps under the drrection of the

cadet officers and staff wherein the General Military Course cadets learn the rudiments of marching and drill and the Professional Officer Course cadets develop their capability to lead, supervise and command marching troops.

FIELD TRAINING

Field Training is held at several Air Force operational bases each summer where cadets have the opportunity to observe, fly and live with career personnel. Transportation from the legal residence of the cadet to the Field Training Base and return, food, lodging and medical and dental care are provided by the Air Force. In addition, the cadet receives approximately $138.00 for the four week Field Training and $131.00 for the six week Field Training.

FIELD TRIPS

Periodically, the Department of Aerospace Studies conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

FLIGHT INSTRUCTION

The Flight Instruction Program (FIP), designed for seniors in the Professional Officer Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio and weather. The flying phase consists of 36½ hours of flight instruction at government expense.

CADET DECORATIONS AND AWARDS

A number of medals are awarded to selected cadets and cadet officers at a special parade and review held each spring. These include the Thomas F. Costello Trophy, the Alumni Medal, the Armed Forces Communications and Electronics Association Award, the Sons of the American Revolution ROTC Award, the Trustees' Medal, the Reserve Officer Association Medal, the Air Force Association Medal, the "Air Force Times" Award, and the Vandenberg Cup.

In addition, the Department of Aerospace Studies confers several medals and awards for outstanding performance in various fields, among them the Distinguished Military Cadet Awards.

Distinguished AFROTC Graduate Awards are given to outstanding graduates, based on academic and military achievements. A recipient of this award may apply for a regular commission as a Second Lieutenant in the United States Air Force.

PHYSICAL EDUCATION

Physical Education contributes to the college curriculum through specific programs of physical fitness, sports, recreational games, gymnastics, tumbling, aquatics, wrestling and judo.

The following objectives serve as guides for the program:

1. The improvement of health through increased organic vigor.
2. The development of efficient and effective sports skills and motor fitness.
3. The development of desirable social attitudes and standards of conduct.
4. The development of an appreciation for and interest in physical activities which will result in continued participation in wholesome and enjoyable leisure pursuits.

Undergraduates must successfully complete two semesters of Physical Education. The semesters are divided into quarters in order to expose students to diverse activities. Classes meet for two one hour periods each week. The Physical Education requirement should be met during the freshman year.

A swimming test is administered to the students during freshman Orientation Week. Students, who fail this test are assigned Swimming for Beginners, P.E. 160. All students in the Physical Education Program shall pass a minimal swimming test before completing their Physical Education requirement.

Next, a Physical Fitness Test is given. Students, who do not meet the minimal satisfactory scores in three (3) of the four (4) test items are assigned Physical Fitness, P.E. 110 for the first quarter. Students, who pass the test are allowed to choose from a list of activities which are offered for each quarter. The Physical Fitness classes are retested at the end of the quarter; students who pass, are then also allowed to choose areas of activities for ensuing quarters.

Participation in varsity and club sports is an integral part of the Physical Education Program; therefore, credit will be given for such participation.

INDIVIDUAL ACTIVITIES

P.E. 110	Physical Fitness
P.E. 115	Individual Sports (handball-squash-paddle racquets)
P.E. 120	Weight Training
P.E. 125	Gymnastics & Tumbling

II TEAM ACTIVITIES

P.E. 130	Basketball
P.E. 135	Hockey
P.E. 140	Soccer
P.E. 145	Softball
P.E. 150	Touch Football
P.E. 155	Volleyball

III AQUATICS

P.E. 160	Swimming for Beginners
P.E. 161	Intermediate Swimming
P.E. 162	Pre Life-saving
P.E. 163	Life Saving
P.E. 164	Competitive Swimming
P.E. 165	Competitive Diving

IV COMBATITIVES

P.E. 170	Judo
P.E. 175	Wrestling

THE FRESHMAN PROGRAM

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Business Administration* or Industrial Management, take the following subjects:

First Semester

**AS	101	World Military Systems I	(1-1)1
CH	001	Chemical Principles	(4-0)3
CH	003	Chemical Principles Laboratory	(0-2)1
LL	111	English I	(3-0)3
MA	107	Calculus and Analytic Geometry	(4-0)4
PH	103	Physics	(4-1)4
		Total Hours	(16-4)16

Second Semester

**AS	102	World Military Systems II	(1-1)1
CH	002	Chemical Principles	(4-0)3
CH	004	Chemical Principles Laboratory	(0-2)1
LL	112	English II	(3-0)3
MA	108	Calculus and Analytic Geometry	(4-0)4
ME	104	Design Graphics	(1-2)1
PH	104	Physics	(4-2)4
		Total Hours	(17-7)17

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. No academic credit is given for the physical education program.

*The freshman program in Business Administration is given on the next page.

Majors in Industrial Management substitute EC 210, Economics I (3-0)3, for PH 103, and EC 202, Economics II (3-0)3, for PH 104.

**Required of all able-bodied, nonveteran male citizens, effective September, 1968.

BUSINESS ADMINISTRATION

The specific objective of the curriculum in Business Administration is to provide an undergraduate professional education for young men and women who have the qualifications and the ambition to be administrators and executives.

The curriculum offers an integration of the tradition l liberal arts subjects and those professional subjects which provide the basic foundations of management science. The emphasis in this area is not technical but administrative. A core of business subjects—accounting, economics, finance, business law, statistics, marketing, production—is required of the student. In the junior year the student is required to concentrate in one of the following fields: accounting,* economics, finance or marketing. This specialization affords the student a deeper penetration of the area he expects to work in after graduation. It is limited, however, in order not to detract from the broad professional goals of the program as a whole.

*Accounting specialization starts in the sophomore year.

FRESHMAN YEAR

First Semester

**AS	101	World Military Systems I	(1-1)1
BA	141	Accounting I	(3-0)3
BA	191	Science and Industry I	(3-0)3
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	101	Mathematical Analysis I	(3-0)3
		Total hours	(16-1)16

Required of all able-bodied, nonveteran male citizens, effective September, 1968.

Second Semester

**AS	102	World Military Systems II	(1-1)1
BA	142	Accounting II	(3-0)3
BA	192	Science and Industry II	(3-0)3
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	102	Mathematical Analysis II	(3-0)3
		Total Hours	(16-1)16

**Required of all able-bodied, nonveteran male citizens, effective September, 1968.

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. No academic credit is given for the physical education program.

SOPHOMORE YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
SS	305	Sociology*	(3-0)3
		English Elective	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	322	Marketing Problems	(3-0)3
EC	212	Economic Statistics II	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
SS	304	Psychology*	(3-0)3
		English Elective	(3-0)3
		Total hours	(15-0)15

*BA 241-242 must be taken by students majoring in Accounting in place of the listed subject.

JUNIOR YEAR

First Semester

BA	332	Money and Banking	(3-0)3
BA	362	Business Law	(3-0)3
BA	371	Production Management I	(3-0)3
EC	301	Economic Development of the U.S.	(3-0)3
		Humanities Elective* *ROTC Students take AS 301	3
		Concentration Elective**	3
		Total credit hours	18

Second Semester

BA	331	Business Finance	(3-0)3
BA	344	Cost Accounting***	(3-0)3
		or	or
BA	346	Managerial Accounting	(2-2)3
BA	372	Production Management II	(3-0)3
EC	302	Labor Economics	(3-0)3
		Humanities Elective* *ROTC Students take AS302	3
		Concentration Elective**	3
		Total credit hours	18

*English, history, political science, economics, or a foreign language. (A two-year commitment is required for a language credit.)

**Concentration areas and subject sequences are:

(A)	Accounting	BA 341, 342, 441, 445,
(B)	Economics	EC 303, 304, 407, 408
(C)	Finance	BA 241, 242, 334, 431
(D)	Marketing	BA 325, 326, 423, 426

The concentration sequence selected by the student must be followed through the senior year unless a waiver is granted by the Department Head.

***Accounting majors take BA 344.

SENIOR YEAR

First Semester

BA	402	International Business	(3-0)3
		or	
BA	444	Advanced Cost Accounting*	
BA	451	Personnel Management	(3-0)3
BA	481	Insurance	(3-0)3
EC	402	Government and Business	(3-0)3
		Concentration Elective	(3-0)3
		Humanities Elective **ROTC Students take AS401	3
		Total credit hours	18

Second Semester

BA	452	Industrial Relations	(3-0)3
BA	492	Transportation	(3-0)3
EC	412	Managerial Economics	(3-0)3
		Concentration Elective	(3-0)3
		Business Elective	(3-0)3
		Humanities Elective **ROTC Students take AS402	3
		Total credit hours	18

*Accounting majors take BA 444.

CHEMICAL ENGINEERING

The Chemical Engineering curriculum provides the student with training for both industrial positions and for further graduate studies. It is designed to give the student a firm foundation in scientific principles and in the application of these principles in the solution of real engineering problems. Sufficient laboratory and design problems are required to give the student a broad understanding of the analysis and solutions to chemical engineering problems.

A strong scientific background is given in the first two years, with the last two years being devoted primarily to chemical engineering and other engineering subjects. Emphasis is placed on both oral and written technical reports in the chemical engineering courses. Some opportunity is provided for original work during the junior and senior years.

The stability of the chemical industry and allied industries, coupled with their strong and continued growth, offers the chemical engineering graduate unparalleled opportunities. The broad chemical engineering training permits him to enter research and development, production, sales and market development areas in business; it also gives him the tools to develop a career which is both stimulating and satisfying.

To be admitted to the Chemical Engineering curriculum, a freshman must have a minimum cumulative rating of 2.0 at the beginning of his sophomore year, or special permission of the Chairman of the Department.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	209	Analytical Techniques	(1-3)2
CN	203	Introduction to Chemical Engineering	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	203	Physics	(4-2)4
		Total Hours	(15-8)17

Second Semester

CH	202	Organic Chemistry	(3-3)4
CN	204	Industrial Stoichiometry	(3-0)3
EE	355	Electrical Controls and Power Circuits	(2-1)3
LL	214	Introduction to American Literature	(3-0)3
MA	206	Differential Equations	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	262	Machine Tool Laboratory	(1-2)1
		Total Hours	(18-6)20

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-3)4
CN	303	Chemical Engineering I	(3-0)3
CN	311	Chemical Engineering Thermodynamics	(3-0)
ME	215	Analytic Mechanics I	(3-0)3
		General Elective*	(3-0)3
		Total Hours	(15-3)16

*ROTC students take AS 301

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
CN	304	Chemical Engineering II	(3-0)3
CN	314	Industrial Instrumentation*	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		Technical Elective	(3-0)3
		General Elective	(3-0)3
		Total Hours	(18-3)19

*ROTC students take AS 302

SENIOR YEAR

First Semester

CN	403	Reactor Design and Kinetics	(3-0)3
CN	411	Unit Operations Laboratory	(0-6)2
EC	201	Economics I	(3-0)3
		Technical Elective*	(3-0)3
		Technical Elective**	(3-0)3
		General Elective	(3-0)3
		Total Hours	(15-6)17

**Recommended Elective:

CN	407	Engineering Analysis of Chemical Processes	(3-0)3

*ROTC students take AS 401

Second Semester

CN	410	Process Analysis and Plant Design	(3-0)3
CN	412	Unit Operations Laboratory	(0-6)2
EC	202	Economics II	(3-0)3
		Technical Elective**	(3-0)3
		General Elective or Technical Elective*	(3-0)3
		Total Hours	(12-6)14

**Recommended Technical Elective:

CN	408	Engineering Materials	(3-0)3

*ROTC students take AS 402

CHEMISTRY

The curriculum in Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry after graduation, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the Committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

Admission to the sophomore year in the chemistry curriculum is contingent upon the student's receiving a minimum grade of C- in each of the two semesters of Chemical Principles (CH 001-002) and Chemical Principles Laboratory (CH 003-004).

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	213	Properties of Electrolytic Solutions	(3-6)5
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics III	(4-2)4
		Total hours	(14-11)17

Second Semester

CH	202	Organic Chemistry	(3-3)4
CH	208	Inorganic Chemistry	(3-0)3
CH	210	Analytical Chemistry	(3-6)5
MA	206	Differential Equations	
		or	(3-0)3
MA	384	Statistical Methods	
PH	206	Physics IV	(4-2)4
		Total hours	(16-11)19

JUNIOR YEAR

First Semester

CH	321	Organic Chemistry Laboratory II	(1-6)3
CH	331	Physical Chemistry	(3-3)4
EC	201	Economics I	(3-0)3
LL	261	Elementary Scientific German	(3-0)3
		General Elective	(3-0)3
		Technical Elective or AS 301	3
		Total credit hours	19

Second Semester

CH	332	Physical Chemistry	(3-3)4
CH	342	Organic Qualitative Analysis	(1-6)3
EC	202	Economics II	(3-0)3
LL	262	Elementary Scientific German	(3-0)3
		General Elective	(3-0)3
		Technical Elective or AS 302	3
		Total credit hours	19

SENIOR YEAR

First Semester

CH	411	Advanced Analytical Chemistry	(2-4)3
CH	443	Advanced Inorganic Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective	3
		Technical Elective or AS 401	3
		Total credit hours	18

Second Semester

CH	444	Advanced Inorganic Chemistry	(3-0)3
		Two General Electives	(6-0)6
		Technical Elective	3
		Technical Elective or AS 402	3
		Total credit hours	15

Seniors are strongly advised to take CH 423-424 (Advanced Organic Chemistry) or CH 431-432* (Advanced Physical Chemistry) as one of the technical electives. Other technical electives include CH 403-404, CH 407-408, and CH 481.*

CIVIL ENGINEERING

Civil Engineering is that branch of engineering charged with the planning, design, construction and operation of works vital to man's activities in his relation to the environment. The concerns of the Civil Engineer include the gathering and processing of environmental informatiion; avenues of transportation; facilities and structures to accommodate domestic, business, industrial, scientific, and recreational pursuits; the control and management of the forces of nature as such affect the environment; the treatment and disposal of solid, liquid and aerial wastes; and the adaptation of materials, natural or man-made, to the works under his control.

Because of the broad range of the civil engineer's activities, this curriculum is first based on a breadth of scientific and engineering principles. Such fundamentals are then expanded into specialized subjects to provide a comprehensive and basic training in the responsibilities of the Civil Engineer.

Graduates of Civil Engineering are prepared to apply their training to the fields of transportation such as highways, railroads, airports, pipelines and waterways; bridges, dams, canals and levees; filtration plants and distribution systems for municipal and industrial water supplies along with sewage and waste treatment plants to protect health. Also in their province are high-rise buildings, power plants, industrial, military and space facilities. After advanced training, the areas of research and teaching are open to them.

SOPHOMORE YEAR

First Semester

CE	201	Surveying I	(3-4)4
EC	201	Economics I	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	211	Mechanics I	(3-0)3
PH	205	Physics III	(4-2)4
		Total hours	(17-6)18

Second Semester

CE	202	Surveying II	(3-4)4
EC	202	Economics II	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	220	Mechanics of Materials I	(3-0)3
PH	206	Physics IV	(4-2)4
		Total hours	(16-6)17

JUNIOR YEAR

First Semester

CE	341	Transportation	(3-3)4
EE	211	Fundamentals of Electricity	(3-0)3
MA	359	Digital Computer Programming	(3-0)3
ME	309	Dynamics	(3-0)3
ME	341	Thermodynamics I*	(3-0)3
		Total hours	(15-3)16

*ROTC students will substitute AS301

Second Semester

CE	312	Structures I	(3-0)3
CE	322	Hydraulics	(4-0)4
EE	212	Introductory Electronics	(3-0)3
EE	214	Electrical Machinery Laboratory	(0-3)1
MA	362	Numerical Analysis*	(3-0)3
ME	314	Mechanical Engineering Laboratory II	(0-3)1
		General Elective	(3-0)3
		Total hours	(16-6)18

*ROTC students will substitute AS302

SENIOR YEAR

First Semester

CE	411	Structures II	(3-3)4
CE	421	Hydrology	(3-3)4
CE	431	Soil Mechanics I	(3-0)3
CE	491	Professional Problems	(3-0)3
LL	209	Technical and Scientific Communication	(2-0)2
		General Elective	(3-0)3
		Total hours	(17-6)19

*ROTC students will substitute AS 401

Second Semester

CE	412	Structures III	(3-3)4
CE	414	Concrete	(3-3)4
CE	432	Soil Mechanics II	(3-3)4
		General Elective	(3-0)3
		Technical Elective*	3
		Total credit hours	18

*ROTC students will substitute AS 402

ELECTRICAL ENGINEERING

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classroom.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences, with considerable choice of subjects allowed. These subjects form an im,ortant part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of non-technical knowledge in determining the student's ultimate level of responsibility in professional life.

The following criteria are used to determine which students from the freshman class are eligible for admission to the Electrical Engineering curriculum:

1. A minimum rating of 2.00 for the second semester of the freshman year.
2. No unremoved failures in freshman subjects.
3. A grade of C (not C-) or higher in MA 108 and PH 104.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	201	Introductory Circuit Theory	(4-0)4
EE	205	Basic Electrical Engineering Laboratory**	(0-3/2)1
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	203	Physics	(4-2)4
		Total Hours	(15-3 ½)15

Second Semester

EC	202	Economics II	(3-0)3
EE	202	Introductory Circuit Theory	(4-0)4
EE	206	Basic Electrical Engineering Laboratory**	(0-3/2)1
MA	206	Differential Equations	(3-0)3
ME	212	Mechanics and Properties of Matter	(4-0)4
		Total Hours	(14-1 ½)15

**The notation 3/2 means that the laboratory meets for 3 hours every other week, and consequently no credit is given for laboratory until the completion of the second semester.

JUNIOR YEAR

First Semester

EE	301	Electronic Devices/Models	(4-0)4
EE	309	Electronic Devices Laboratory	(0-3)1
EE	315	Network Analysis	(4-0)4
		or	or
EE	317	Digital Computers-Applications and Programming	(2-2)4
MA	313	Engineering Mathematics	(4-0)4
		General Elective (from approved list)*	(3-0)3
		Total credit hours	16

*ROTC students take AS301

Second Semester

EE	302	Electronic Devices/Models	(4-0)4
EE	306	Electromagnetic Theory	(4-0)4
EE	310	Electronic Devices Laboratory	(0-3)1
EE	317	Digital Computers-Applications & Programming	(2-2)4
		or	or
EE	315	Network Analysis	(4-0)4
		General Elective (from approved list)*	(3-0)3
		Total credit hours	16

*ROTC students take AS 302

SENIOR YEAR

First Semester

ME	347	Elements of Thermodynamics and Heat Transfer	(3-0)3
		EE Technical Electives	6
		General Elective (from approved list)	3
		Free Elective*	3
		Total credit hours	15

*ROTC students take AS 401

Second Semester

Technical Electives	6
General Elective (from approved list)	3
Free Elective	3
Free Elective*	3
Total credit hours	15

*ROTC students take AS 402

ROTC students must choose a general elective (from approved list).

INDUSTRIAL MANAGEMENT

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide a student with a foundation in science and engineering, in the humanities, and in the social sciences. In addition, the various aspects of management—production, marketing, accounting, and finance—are learned. The student extends his knowledge of mathematics to include economic statistics and statistical quality control. He is also introduced to the newer research methods, including operations research, linear programming, and game theory. A graduate of this program can qualify for employment in accounting, procurement, production management, technical sales, or personnel management, depending on the concentration area he chooses.

SOPHOMORE YEAR

First Semester

BA	141	Accounting I	(3-0)3
BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
ME	261	Machine Tool Laboratory	(1-2)1
PH	103	Physics	(4-1)4
		English Elective	(3-0)3
		Total hours	(17-3)17

Second Semester

BA	142	Accounting II	(3-0)3
BA	322	Marketing Problems	(3-0)3
EC	212	Economic Statistics II	(3-0)3
PH	104	Physics	(4-2)4
		English Elective	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

BA	331	Business Finance	(3-0)3
BA	371	Production Management I	(3-0)3
IM	351	Motion and Time Study	(0-2)1
ME	315	Applied Mechanics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
PH	203	Physics	(4-2)4
		Concentration Elective*	3
		Total credit hours	19

*Concentration areas and subject sequences are:

(A)	Air Science	AS 301,302,401,402.
(B)	Economics	EC 303, 304, 407, 408.
(C)	Accounting	BA 241, 242, 341, 342.
(D)	Finance	BA 241, 242, 431, 334.
(E)	Marketing	BA 325, 326, 423, 426.
(F)	Mathematics MA 205, 206, plus two additional courses approved by Department Head	

The concentration sequence selected by the student must be followed through the senior year unless a waiver is granted by the Department Head.

Second Semester

BA	332	Money and Banking	(3-0)3
BA	344	Cost Accounting**	(3-0)3
		or	or
BA	346	Managerial Accounting	(2-2)3
BA	372	Production Management II	(3-0)3
EC	302	Labor Economics	(3-0)3
ME	372	Strength of Materials	(3-0)3
		Concentration Elective	(3-0)3
		Total credit hours	18

SENIOR YEAR

First Semester

BA	451	Personnel Management	(3-0)3
EE	351	Industrial Electronics	(3-0)3
IM	371	Operations Research	(3-0)3
IM	483	Statistical Quality Control	(3-0)3
		Management Elective*	(3-0)3
		Concentration Elective	3
		Total credit hours	18

Second Semester

BA	362	Business Law	(3-0)3
EC	402	Government and Business	(3-0)3
EC	412	Managerial Economics	(3-0)3
ME	344	Heat and Power	(3-0)3
		Management Elective*	(3-0)3
		Concentration Elective	3
		Total credit hours	18

*The student may select a subject bearing a BA, EC, or IM designation, or SS303 or SS 305. Accounting majors must take BA 444 in first semester.

**Accounting majors take BA 344.

MATHEMATICS

The objectives of the Mathematics program are twofold: (1) to provide the student with the opportunity to become acquainted with the major areas of modern mathematics—algebra, analysis, geometry and applied mathematics, including computing science and numerical analysis, and (2) to enable him to achieve a certain mastery in depth of one or more of these areas.

The approaces to these objectives are also twofold, viz., by way of course work and supervised project activity. In order to achieve breadth, each of the major areas mentioned above is represented by at least one required three-hour subject. A deeper study of one or more areas is provided by the student's elective program, subject to the approval of his departmental advisor.

The purpose of the project work is to enable the student to "read, write, and speak" mathematics, via the reading of simple journal articles, the preparation of short papers, and oral presentations. This aspect of the program is regarded as at least as important as the formal course work. Participation in a working seminar is required of all mathematics majors, during both junior and senior years.

As designed, the curriculum exceeds the minimum recommendations of the Committee on Undergraduate Programs in Mathematics of the Mathematical Association of America for college mathematics programs. It provides a strong basis both for subsequent graduate study and for employment in the several fields as involved in teaching and industry.

A student may be admitted to the Mathematics major program, provided he has attained a cumulative rating of at least 2.00 by September of his sophomore year, and his mathematics grades are better than c-.

SOPHOMORE YEAR

First Semester

MA	205	Calculus and Analytic Geometry	(4-0)4
MA	221	Linear Algebra	(3-0)3
PH	203	Physics	(4-2)4
		Approved Modern Foreign Language	(3-0)3
		General Elective	(3-0)3
		Total hours	(17-2)17

Second Semester

MA	206	Differential Equations	(3-0)3
MA	222	Linear Algebra	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
		Approved Modern Foreign Language	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	18

JUNIOR YEAR

First Semester

MA	307	Advanced Calculus	(3-0)3
MA	321	Modern Algebra	(3-0)3
MA	395	Mathematics Seminar	(1-0)1
		Applied Mathematics Elective*	(3-0)3
		Technical or General Elective	3
		General Elective	(3-0)3
		Total credit hours	16

*To be selected from an approved departmental list.

Second Semester

MA	308	Advanced Calculus	(3-0)3
MA	334	Projective Geometry	(3-0)3
MA	396	Mathematics Seminar	(1-0)1
		Mathematics Elective	(3-0)3
		Technical or General Elective	3
		General Elective	(3-0)3
		Total credit hours	16

SENIOR YEAR

First Semester

MA	411	Complex Variables I	(3-0)3
MA	431	Topology I	(3-0)3
MA	495	Mathematics Seminar	(1-0)1
		Mathematics Elective	(3-0)3
		Technical or General Elective	3
		General Elective	(3-0)3
		Total credit hours	16

Second Semester

MA	496	Mathematics Seminar	(1-0)1
		Two Mathematics Electives	6
		Technical or General Elective	3
		General Elective	(3-0)3
		Total credit hours	13

MECHANICAL ENGINEERING

Mechanical Engineering is a diversified professional activity. The mechanical engineer is called upon to develop new methods of energy production and conversion, transportation, manufacture, and fabrication.

Because of the diversification of mechanical engineering, it is not possible for a student to master the entire field during a four year program. The objective of this curriculum is to provide a broad fundamental base from which the graduate can go on to develop his skills by either entering general engineering practice or pursuing an advanced engineering degree.

The curriculum is designed to achieve this objective by means of a three phase program.

The first phase consists of acquiring a background in humanistic-social studies, and the basic sciences. The purpose of the first phase is to broaden the student's outlook and provide a firm understanding of fundamentals, develop analytical techniques, and to prepare for specific technical subjects.

The second phase consists of acquiring a knowledge in a coherent area of engineering science. The purpose of this phase is to form the link between the basic sciences and engineering, and to introduce the methodology of engineering analysis, design and synthesis. Three areas of engineering science have been selected for this phase; namely, applied mechanics (statics, dynamics and mechanics of materials), thermal-transport (thermodynamics, fluid mechanics and heat transfer), an automatic controls (electricity, electronics, measurements, and control systems).

In the final phase of the curriculum, advanced problems and topics are considered in engineering design. The purpose of the design activity is to develop skill in the use of science and creativity to solve engineering problems and thus requires the utilization of the first two phases.

A variety of laboratory work is included in the curriculum in order to demonstrate the use of the experimental method in the solution of engineering problems.

To permit a degree of specialization, four technical electives are provided in the senior year. A staff advisor system is used in order to aid the student in selecting technical electives so that the subjects will be consistent with the future career plans of the student.

This curriculum is accredited by the Engineers' Council for Professional Development.

To be admitted to the Mechanical Engineering Curriculum, a freshman must have a minimum cumulative rating of 2.00 at the beginning of his sophomore year.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	211	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	203	Manufacturing Techniques and Communication	(2-1)2
ME	211	Mechanics I	(3-0)3
PH	203	Physics	(4-2)4
		Total hours	(19-3)19

Second Semester

EC	202	Economics II	(3-0)3
EE	212	Introductory Electronics	(3-0)3
MA	206	Differential Equations	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	220	Mechanics of Materials I	(3-0)3
ME	276	Material Science	(3-2)3
		Total hours	(18-2)18

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
ME	301	Mechanical Engineering Laboratory I	(0-3)1
ME	309	Dynamics I	(3-0)3
ME	341	Thermodynamics I	(3-0)3
ME	351	Measurement	(3-0)3
		General Elective*	(3-0)3
		General Elective	(3-0)3
		Total hours	(18-3)19

*ROTC students take AS 301

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
ME	314	Mechanical Engineering Laboratory II	(0-3)1
ME	320	Machine Design I	(2-3)3
ME	342	Thermodynamics II	(3-0)3
ME	382	Fluid Mechanics I	(3-0)3
		General Elective*	(3-0)3
		Total hours	(14-6)16

*ROTC students take AS 302

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory III	(0-3)1
ME	417	Dynamics II	(3-0)3
ME	443	Heat Transfer	(3-0)3
ME	497	Automatic Control Systems I	(3-0)3
		General Elective	(3-0)3
		Technical Elective*	3
		Total credit hours	16

*ROTC students take AS 401

TECHNICAL ELECTIVES

Group A			
ME	441	Statistical Thermodynamics	(3-0)3
ME	473	Mechanics of Materials II	(3-0)3
Group B			
ME	419	Nondestructive Evaluation Techniques	(3-0)3
ME	475	Physical Metallurgy	(3-0)3

Second Semester

ME	416	Senior Project	(0-3)1
ME	430	Design of Mechanical Systems	
		or	(3-0)3
ME	442	Design of Thermal Systems	
		General Elective	(3-0)3
		Technical Elective*	3
		Technical Elective	3
		Technical Elective	3

*ROTC students take AS 402

TECHNICAL ELECTIVES

Group A			
ME	482	Fluid Mechanics II	(3-0)3
ME	498	Automatic Control Systems II	(3-0)3
ME	562	Engineering Analysis	(3-0)3
Group B			
ME	422	Machine Design II	(2-3)3
ME	446	Energy Conversion	(3-0)3
ME	452	Applications of Numerical Analysis	(3-0)3
ME	468	Fluid Machinery	(3-0)3
ME	472	Experimental Stress Analysis	(2-3)3
ME	488	Environmental Conditioning	(3-0)3
ME	528	Kinematic Mechanism Synthesis	(3-0)3

A minimum of one half of a student's total number of technical electives must come from Group A.

METEOROLOGY

Meteorology is the study of the physical and chemical processes that occur in the atmosphere and between the atmosphere and the earth's surface. The advent of space exploration has broadened the scope of meteorology to include atmospheres of the other planets.

The work of meteorologists is concentrated on the effort to understand the physical causes of weather and climate and to apply the knowledge gained to the solution of practical problems ranging from the forecasting of tomorrow's weather for the general public to the analysis of the influence of weather and climate on particular operations in agriculture, engineering, industry and commerce, national defense and public health. Meteorologists are employed in these capacities by the agencies of the Environmental Science Services Administration, especially the Weather Bureau, by agencies of the Defense Department and by commercial aviation companies and private consulting firms. Meteorological research conducted by agencies of the U. S. Government, universities and private research companies is becoming increasingly important as a field of employment. Although graduate training is essential for advancement in this field, the U. S. Government and most private employers provide opportunities for individuals to acquire this training. The bachelor of science curriculum prepares the student for a career as a meteorologist in government or private industry and provides a sound foundation for graduate study.

The freshman year is the same as that for the other programs in science and engineering. In order to enter the sophomore year, the student must have a cumulative rating of at least 2.00 for the second semester of the freshman year and grades of at least C in both physics and mathematics.

SOPHOMORE YEAR

First Semester

LL	261	Elementary Scientific German	
		or	(3-0)3
LL	263	Elementary French	
		or	(3-0)3
LL	265	Elementary Russian	
		or	
LL	267	Elementary Spanish	(4-0)4
MA	205	Calculus and Analytic Geometry	(4-2)4
PH	203	Physics	3
		General Elective	3
		General or Technical Elective	
		Total credit hours	17

Second Semester

LL	262	Elementary Scientific German	
		or	
LL	264	Elementary French	
		or	(3-0)3
LL	266	Elementary Russian	
		or	
LL	268	Elementary Spanish	
MA	206	Differential	(3-0)3
MY	202	General Meteorology	(3-0)3
		Technical Elective	3 or 4
		General Elective	3
		Total credit hours	15 or 16

JUNIOR YEAR

First Semester

MA	359	Digital Computer Programming	(3-0)3
MA	383	Statistical Methods	(3-0)3
MY	303	Atmospheric Physics	(3-0)3
MY	305	Synoptic Meteorology	(1-6)3
		Technical or General Elective	3
		Total credit hours	15

Second Semester

MA	362	Numerical Analysis	(3-0)3
MY	304	Atmospheric Physics	(3-0)3
MY	306	Physical Climatology	(3-0)3
		General and Technical Electives	6
		Total credit hours	15

SENIOR YEAR

First Semester

MY	401	Weather Analysis and Forecasting	(0-9)3
MY	403	Physical Meteorology	(3-0)3
MY	405	Individual Studies	(1-0)1
MY	407	Hydrometeorology	(2-0)2
		General Elective	3
		Technical Elective	3
		Total credit hours	15

Second Semester

MY	402	Weather Analysis and Forecasting	(0-9)3
MY	406	Individual Studies	(1-0)1
MY	408	Hydrometeorology	(2-0)2
MY	410	Statistical Methods in Meteorology	(3-3)4
		General Elective	3
		Technical Elective	3
		Total credit hours	16

NUCLEAR ENGINEERING

The Nuclear Engineering course was the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for responsible positions in industry or for study at the graduate level.

The following minimum standards for entrance to the sophomore year of the program must be met by September. A cumulative average of 2.00, no unremoved failures, and grades of C or better in freshman physics and mathematics. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
NU	201	Introduction to Nuclear Engineering	(3-0)3
PH	205	Physics III	(4-2)4
		General Elective	(3-0)3
		Total Hours	(17-2)17

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	206	Differential Equations	(3-0)3
NU	202	Introduction to Nuclear Engineering	(3-0)3
PH	206	Physics IV	(4-2)4
		General Elective	(3-0)3
		Total Hours	(16-2)16

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
ME	341	Thermodynamics I	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
PH	363	Introductory Nuclear Physics*	(3-0)3
		General Elective	(3-0)3
		Total Hours	(14-4)16

*ROTC students will substitute AS 301

JUNIOR YEAR

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
NU	302	Radiological Health*	(3-0)3
NU	306	Nuclear Instrumentation	(2-4)4
PH	366	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total Hours	(14-4)16

*ROTC students will substitute AS 302

SENIOR YEAR

First Semester

CH	481	Radiochemistry	(3-3)4
ME	443	Heat Transfer	(3-0)3
NU	405	Nuclear Reactor Engineering	(3-0)3
NU	493	Advanced Nuclear Laboratory*	(0-6)3
		General Elective	(3-0)3
		Total Hours	(12-9)16

*ROTC students will substitute AS 401

Second Semester

CH	484	Elements of Radiochemistry	(3-3)4
ME	382	Fluid Mechanics I	(3-0)3
NU	406	Nuclear Reactor Engineering	(3-0)3
NU	494	Advanced Nuclear Laboratory*	(0-6)3
		General Elective	(3-0)3
		Total Hours	(12-9)16

*ROTC students will substitute AS 402

PAPER ENGINEERING

The Paper Engineering curriculum is basically chemical engineering with a minor in Paper Engineering. Emphasis is placed on an engineering analysis of the paper industry, its production methods, fundamental properties of its raw materials and the unit operations involved in manufacture of paper and allied products. Graduates of this curriculum go either into industry directly or continue on with further graduate studies.

In its position as the fifth largest industry in the United States, the paper and allied industries offer both stability and growth potential. The increasing complexities of pulp and paper operations, and the growth of the converting industry, involving plastics, chemicals, metals and other materials have created an intense and growing demand for men trained in the fundamentals of engineering science with a broad background of practical problem solving. These prerequisites are supplied by this curriculum and close liaison is maintained between the staff and industry. Graduates of the Paper Engineering course are qualified to enter the paper industry (an its allied industries) in research and development, production, sales or market development. Many shortly find themselves in management positions.

The interest of the paper industry in Paper Engineering students is evidenced by the generous scholarships available to students enrolled in this program. Ten to twelve $500 scholarships are granted to upper classmen each year who qualify with appropriate scholastic records.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	209	Analytical Techniques	(1-3)2
CN	203	Introduction to Chemical Engineering	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	203	Physics	(4-2)4
		Total H ours	(15-8)17

Second Semester

CH	202	Organic Chemistry	(3-3)4
CN	204	Industrial Stoichiometry	(3-0)3
EE	355	Electrical Controls and Power Circuits	(2-1)3
LL	214	Introduction to American Literature	(3-0)3
MA	206	Differential Equations	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	262	Machine Tool Laboratory	(1-2)1
		Total Hours	(18-6)20

JUNIOR YEAR

First Semester

CH	225	Principles of Physical Chemistry	(3-3)4
CN	303	Chemical Engineering I	(3-0)3
CN	311	Chemical Engineering Thermodynamics	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
PA	301	Engineering Analysis of Pulp Systems	(3-0)3
PA	307	Physical Testing and Analysis of Data*	(3-0)3
		Total Hours	(15-3)19

*ROTC students will substitute AS 301

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
CN	304	Chemical Engineering II	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
PA	302	Engineering Analysis of Paper Systems	(3-0)3
PA	308	Pulp and Paper Laboratory	(0-6)2
		General Elective*	(3-0)3
		Total Hours	(15-9)18

*ROTC students take AS 302

SENIOR YEAR

First Semester

CN	313	Industrial Instrumentation*	(3-0)3
CN	411	Unit Operations Laboratory	(0-6)2
EC	201	Economics I	(3-0)3
PA	403	Engineering Analysis of Converting Processes	(3-0)3
PA	405	Converting Laboratory	(0-6)2
		General Elective	(3-0)3
		Total Hours	(12-12)16

*ROTC students will substitute AS 401

Second Semester

CN	412	Unit Operations Laboratory	(0-6)2
EC	202	Economics II	(3-0)3
PA	410	General Analysis of Paper Processing	(3-0)3
		Technical Elective* or General Elective	(3-0)3
		General Elective	(3-0)3
		Total Hours	(12-6)14

*ROTC students will substitute AS 402

PHYSICS

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

The following minimum standards for entrance to the sophomore year of the program must be met by September: A cumulative average of 2.00 and no unremoved failures; in freshman physics and mathematics courses only, a cumulative average of 2.50 and no unremoved grades below C-. A student in the program is expected to do much better than this minimum.

There is also an Option in Nuclear Physics, to be described further below.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
LL	261	Elementary Scientific German	
		or	
LL	263	Elementary French	(3-0)3
		or	
LL	265	Elementary Russian	
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	205	Physics III	(4-2)4
PH	293	Laboratory Practice	(1-3)2
		Total hours	(15-5)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
LL	262	Elementary Scientific German	
		or	
LL	264	Elementary French	(3-0)3
		or	
LL	266	Elementary Russian	
MA	206	Differential Equations	(3-0)3
PH	206	Physics IV	(4-2)4
PH	294	Laboratory Practice	(0-6)2
		Total hours	(13-8)15

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
PH	311	Intermediate Mechanics	(3-0)3
PH	345	Atomic and Nuclear Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	393	Experimental Physics	(0-6)2
		General Elective*	(3-0)3
		Total hours	(15-6)17

*ROTC students will substitute AS 301

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
PH	312	Intermediate Mechanics	(3-0)3
PH	346	Atomic and Nuclear Physics	(3-0)3
PH	354	Electromagnetic Theory	(3-0)3
PH	394	Experimental Physics	(0-6)2
		General Elective*	(3-0)3
		Total hours	(15-6)17

*ROTC students will substitute AS 302

SENIOR YEAR

First Semester

PH	423	Thermodynamics	(3-0)3
PH	493	Advanced Laboratory	(1-3)2
		2 Approved Technical Electives*	6
		General Elective	3
		Technical or General Elective	3
		Total credit hours	17

Technical Electives

PH	411	Quantum Theory	(3-0)3
PH	445	X-Ray Diffraction	(2-3)3
PH	471	Solid State Physics	(3-0)3
PH	497	Biophysics Seminar	(1½-0)1
PH	552	Astrophysics	(3-0)3
MA	411	Complex Variables I	(3-0)3
MA	484	Probabilities	(3-0)3
MA	575	Operational Mathematics	(3-0)3

Second Semester

PH	348	Physical Optics	(3-0)3
		or	
PH	436	Theory of Waves	
PH	494	Advanced Laboratory	(1-3)2
		2 Approved Technical Electives*	6
		General Elective	3
		Technical or General Elective	3
		Total credit hours	17

Technical Electives

PH	412	Quantum Theory	(3-0)3
PH	424	Introduction to Statistical Mechanics (Prereq. MA 484)	(3-0)3
PH	448	Electron Microscopy and Electron Diffraction	(2-3)3
PH	454	Piezoelectric Crystals	(2-3)3
PH	472	Solid State Physics	(3-0)3
PH	498	Biophysics Seminar	(1½-0)1
MA	434	Matrix Algebra	(3-0)3
MA	542	Fourier Series and Boundary Value Problems	(3-0)3

*One of these may be an Air Science subject.

OPTION IN NUCLEAR PHYSICS

The Option in Nuclear Physics emphasizes those fundamental subjects in physics and mathematics that are necessary for the basic education of a physicist who desires to work in this field, and thus prepares the graduate for advanced studies as well as for responsible activity in industry. The first three years are identical with those of the regular Physics curriculum. (Note: NU 305-306 Nuclear Instrumentation may be substituted for PH 393-394, in which case PH 493-494 will be taken in the Senior year.(Naturally, the same academic requirements apply in this option.

OPTION IN NUCLEAR PHYSICS

SENIOR YEAR

Beginning with Class of 1970

First Semester

NU	305	Nuclear Instrumentation	(2-4)4
PH	363	Introductory Nuclear Physics	(3-0)3
PH	423	Thermodynamics	(3-0)3
		Approved Technical Elective*	3
		General Elective	3
		Technical or General Elective	3
		Total credit hours	19

Technical Electives

PH	411	Quantum Theory	(3-0)3
PH	445	X-Ray Diffraction	(2-3)3
PH	471	Solid-State Physics	(3-0)3
PH	497	Biophysics Seminar	(1½-0)1
MA	411	Complex Variables I	(3-0)3
MA	484	Probabilities	(3-0)3
MA	575	Operational Mathematics	(3-0)3

*ROTC students will substitute AS 401

Second Semester

NU	306	Nuclear Instrumentation	(2-4)4
PH	348	Physical Optics	
		or	(3-0)3
PH	436	Theory of Waves	
PH	366	Intermediate Nuclear Physics	(3-0)3
		Approved Technical Elective*	3
		General Elective	3
		Technical or General Elective	3
		Total credit hours	19

Technical Electives

CH	484	Elements of Radiochemistry	(3-3)4
NU	302	Radiological Health	(3-0)3
PH	412	Quantum Theory	(3-0)3
PH	424	Introduction to Statistical Mechanics (Prereq. MA 484)	(3-0)3
PH	448	Electron Microscopy and Electron Diffraction	(2-3)3
PH	454	Piezoelectric Crystals	(2-3)3
PH	462	Nuclear Physics	(3-0)3
PH	472	Solid-State Physics	(3-0)3
PH	498	Biophysics Seminar	(1½-0)1
MA	434	Matrix Algebra	(3-0)3
MA	542	Fourier Series and Boundary Value Problems	(3-0)3

*ROTC students will substitute AS 402

SENIOR YEAR

Class of 1969

First Semester

PH	345	Atomic and Nuclear Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
PH	423	Thermodynamics	(3-0)3
PH	493	Advanced Laboratory	(1-3)2
		Approved Technical Elective*	3
		General Elective	3
		Total credit hours	17

*ROTC students will substitute AS 401

Second Semester

Second Semester

PH	348	Physical Optics	
		or	(3-0)3
PH	436	Theory of Waves	
PH	354	Electromagnetic Theory	(3-0)3
PH	494	Advanced Laboratory	(1-3)2
		Approved Technical Elective*	3
		General Elective	3
		Technical or General Elective	3
		Total credit hours	17

*ROTC students will substitute AS 402

PLASTICS TECHNOLOGY

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials.

However, the close relationship existing between the physical behavior and chemical structure of polymers makes it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics, and quality control augment the basic courses in mathematics, sciences, engineering, and plastics technology to round out a well balanced program.

Students electing Plastics Technology are privileged to become affiliated with the first sutdent chapter of the International Society of Plastics Engineers, an opportunity which affords each student member an early and rewarding professional association.

SOPHOMORE YEAR

First Semester

CH	201	Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-4)4
MA	205	Calculus and Analytic Geometry	(4-0)4
PH	203	Physics	(4-2)4
PL	201	Introduction to Polymeric Materials	(2-0)2
		Total Hours	(16-9)18

Second Semester

CH	202	Organic Chemistry	(3-3)4
CH	206	Qualitative Analysis	(3-0)3
LL	314	Continental Literature Since the Renaissance	(3-0)3
MA	384	Statistical Methods	(3-0)3
PL	202	Introduction to Polymeric Materials	(2-0)2
		Elective*	(3-0)3
		Total Hours	(17-3)18

*MA 206 Differential Equations recommended for advanced degree study.

JUNIOR YEAR

First Semester

CH	335	Principles Physical Chemistry	(3-3)4
EC	201	Economics I*	(3-0)3
EE	355	Electrical Controls and Power Circuits	(2-1)3
ME	215	Analytic Mechanics I	(3-0)3
ME	261	Machine Tool Laboratory	(1-2)1
PL	301	Plastics Technology	(2-2)3
		Total Hours	(14-8)17

*ROTC students will substitute AS 301

Second Semester

CH	336	Principle of Physical Chemistry	(3-3)4
EC	202	Economics II*	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
ME	374	Plastics Mold Design and Construction	(1-2)1
ME	276	Materials Science	(3-2)3
PL	302	Plastics Technology	(2-2)3
		Total Hours	(15-9)17

*ROTC students will substitute AS 302

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
ME	493	Industrial Instrumentation	(2-0)2
PL	401	Plastics Technology	(2-2)3
PL	403	Properties of Polymers	(2-2)3
PL	411	Plastics Seminar	(1-0)1
		Elective	(3-0)3
		Total Hours	(13-8)16

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
ME	384	Fluid Mechanics	(3-0)3
PL	402	Plastics Technology	(2-2)3
PL	404	Properties of Polymers	(2-2)3
PL	412	Plastics Seminar	(1-0)1
		Elective	(3-0)3
		Total Hours	(14-8)17

Suggested Electives

CH	423-424	Advanced Organic Chemistry	(3-0)(3-0)6
IM	483	Statistical Qaulity Control	(3-0)3
LL	209	Technical and Scientific Communication	(3-0)3
LL	261-262	Elementary Scientific German	(3-0)(3-0)6
MA	206	Differential Equations	(3-0)3
MA	359 or 360	Scientific Computer Programming	(3-0)3

TEXTILE ENGINEERING

The object of this curriculum in Textile Engineering is to provide the student with a firm understanding of scientific principles and their application to the Textile industry and its related branches.

During the first two years the student is thoroughly instructed in basic mathematics, physics, and chemistry. This fundamental work is followed by more specialized training in the field of Textiles and related areas of Mechanical Engineering.

A wide range of laboratory work is included in the curriculum in order to demonstrate both the use of the experimental method in the solution of engineering problems and to give a practical understanding of textile procedure.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	211	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	203	Manufacturing Techniques and Communication	(2-1)2
ME	215	Analytic Mechanics I	(3-0)3
PH	203	Physics	(4-2)4
		Total hours	(19-3)19

Second Semester

EC	202	Economics II	(3-0)3
EE	212	Introductory Electronics	(3-0)3
MA	206	Differential Equations	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
TE	212	Fiber Science	(3-1)3
TE	264	Textile Systems I	(3-1)3
		Total hours	(18-2)18

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	345	Thermodynamics	(3-0)3
ME	377	Elements of Materials Science*	(2-0)2
TE	363	Textile Systems II	(3-1)3
TE	365	Textile Systems III	(3-2)3
		General Elective	(3-0)3
		Total hours	(17-3)17

*ROTC students will substitute AS 301

Second Semester

EE	323	Electrical Energy Conversion*	(3-2)4
MA	360	Digital Computer Programming	(3-0)3
ME	314	Mechanical Engineering Laboratory II	(0-3)1
ME	384	Fluid Mechanics	(3-0)3
TE	366	Textile Systems IV	(3-2)3
		General Elective	(3-0)3
		General Elective	(3-0)3
		Total hours	(18-7)20

*ROTC students will substitute AS 302.

SENIOR YEAR

First Semester

ME	415	Mechanical Engineering Laboratory III	(0-3)1
ME	421	Machine Design	(2-3)3
ME	445	Heat Transfer	(3-0)3
ME	495	Electromechanical Engineering	(3-0)3
TE	459	Textile Systems V	(2-1)2
TE	483	Engineering Design of Textile Structures	(3-0)3
		General Elective*	(3-0)3
		Total hours	(16-7)18

*ROTCIstudents take AS 401

Second Semester

ME	416	Senior Project	(0-3)1
TE	472	Textile Evaluation	(2-3)3
TE	482	Application of Scientific Methods to Textile Processes	(3-0)3
TE	484	Engineering Design of Textile Structures	(3-0)3
TE	460	Textile System VI	(1-2)2
		General Elective	(3-0)3
		Technical Elective (Textile)	3
		Total credit hours	18

*ROTC students take AS 402

TEXTILE TECHNOLOGY

This course of study is designed to equip its students with a well-rounded understanding of the theory and principles relating to the processing of textile materials. At the same time it provides the scientific basis necessary to understand and apply this technological knowledge. Basic purpose of the program is to prepare students to become competent textile technologists for eventual supervisory, administrative, or executive positions within the industry and its allied fields. To achieve this end, a comprehensive course covers the basic theory, principles, and applications of the major phases of textile manufacture utilizing all the common fibers, both natural and man-made, and all fabricating processes.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	211	Fundamentals of Electricity	(3-0)3
MA	205	Calculus and Analytic Geometry	(4-0)4
ME	215	Analytic Mechanics I	(3-0)3
PH	203	Physics	(4-2)4
		Total hours	(17-2)17

Second Semester

EC	202	Economics II	(3-0)3
EE	212	Introductory Electronics	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	203	Manufacturing Techniques and Communication	(2-1)2
ME	216	Analytic Mechanics II	(3-0)3
TE	212	Fiber Science	(3-1)3
		Total hours	(17-2)17

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
TE	305	Textile Mechanism	(3-0)3
TE	335	Design and Analysis of Woven Structures	(3-0)3
TE	411	Technology of Yarns I	(2-2)3
		General Elective	(3-0)3
		Total hours	(16-2)17

Second Semester

EE	323	Electrical Energy Conversion	(3-2)4
ME	344	Heat and Power	(3-0)3
ME	384	Fluid Mechanics	(3-0)3
TE	336	Fabric Technology I	(2-2)3
TE	412	Technology of Yarns II	(2-2)3
		General Elective	(3-0)3
		Total hours	(16-6)19

SENIOR YEAR

First Semester

ME	421	Machine Design*	(2-3)3
TE	433	Technology of Knitting	(2-2)3
TE	437	Fabric Technology II	(2-2)3
TE	457	Technology of Finishing I	(3-0)3
TE	483	Engineering Design of Textile Structures I	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-7)18

*Recommended, but may be substituted by a textile or other approved elective.

Second Semester

TE	458	Technology of Finishing II	(1-2)2
TE	472	Textile Evaluation	(2-3)3
TE	474	Instrumentation for Textiles	(2-2)3
TE	484	Engineering Design of Textile Structures II	(3-0)3
TE	485	Statistical Quality Control—Textile	(3-0)3
		General Elective	(3-0)3
		Total hours	(14-7)17

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS Aerospace Studies
BA Business Administration
CE Civil Engineering
CH Chemistry
CN Chemical Engineering
EC Economics
EE Electrical Engineering
IM Industrial Management
LL Languages and Literature
MA Mathematics
ME Mechanical Engineering
MY Meteorology
NU Nuclear Engineering
PA Paper
PH Physics
PL Plastics
SS Social Sciences
TE Textiles

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are restricted to graduate students. An asterisk following the subject number, e.g., PH 411-412*, indicates a subject which, although is primarily for undergraduates, may, under certain circumstances, be taken for full graduate credit.

Odd numbers usually designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Some subjects are given both semesters without change in number. Hyphenated numbers indicate subjects continuing throughout the year.

Prerequisites and restrictions are shown in brackets, e.g., [*CH 423*]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

AEROSPACE STUDIES

AS 101-102 World Military Systems I (1-1) (1-1)2

An introductory course exploring the causes of the present world confilict, the role and relationship of military power to the conflict and the responsibility of an Air Force Officer. The course begins with a brief study of war and the principles of war. It continues with an examination of the factors of national power, the instruments tht nations use to pursue their objectives and how these relate to the varying scopes and intensities of conflict. This is followed by a broad discussion of the US military establishment and the relationship of the three military services within the DOD. The course ends with an examination of the specific functions of US Strategic Offensive and Devensive Forces in depth.

AS 201-202 World Military Systems II (1-1) (1-1)2

A continued study of world military forces with a review of the organizational structure, mission, operations and hardware of US Forces. This is followed by an analysis of the US General Purpose Forces, the US Aerospace Support Forces and a study of the specific contributions of each to US national objectives. The course ends with the study of the source of conflict in the world today and an assessment of the progress and prospects for peace in the future.

AS 301-302 Growth and Development of Aerospace Power I and II (3-1) (3-1)6

A survey course about the nature of war; development of airpower in the United States; mission and organization of the Defense Department; Air Force concepts, doctrine and employment; astronautics and space operations; and the future development of aerospace power, including US space programs, vehicles, systems, and problems in space exploration. The above areas are studies through the media of briefings, discussions, debates and written reports by the student to improve his communicative skills.

AS 401-402 The Professional Officer I and II (3-1) (3-1)6

A study of professionalism, leadership, and management, including the meaning of professionalism; professional responsibilities; the military justice system; leadership theory, functions and practices; management principles, and functions;

problem solving; and management tools, practices and controls. The above areas are studied through the media of discussions, briefings and written reports by the student to improve his ability to communicate.

BUSINESS ADMINISTRATION

BA 141-142 Accounting I and II (3-0) (3-06

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 191-192 Science and Industry I and II (3-0) (3-0)6
[For BA students only]

A review of the major science areas with particular attention to their application in industry.

BA 241-242 Accounting III and IV (3-0) (3-0)6
[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 Marketing Principles (3-0)3
[EC 202, or EC 201 taken concurrently]

Analysis of modern methods of marketing and merchandising as they are related to consumer, producer and middleman.

BA 322 Marketing Problems (3-0)3
[BA 321]

An analytic approach to marketing strategy in relation to the problems of organization, coordination, and control. Price policies, the government's role in marketing, and physical distribution.

BA 325 Advertising (3-0)3
[BA 321]

The relation of advertising to modern business organization and its place in marketing and distribution.

BA 326 **Marketing Research** **(3-0)3**
[BA 321, EC 212]

Measuring potential, design of experiments, data collection, sampling, questionnaires, study of promotional efforts, market testing, and controls.

BA 331 **Business Finance** **(3-0)3**
[BA 142, EC 202]

Principles of financial management, including working and fixed capital, sources of funds, financial statements, budgeting and capitalization.

BA 332 **Money and Banking** **(3-0)3**
[EC 201]

The role of money and monetary policy in the United States. The banking structure, the Federal Reserve System, other financial institutions, and international monetary systems.

BA 334 **Investment Management** **(3-0)3**
[BA 331]

Principles of investment, including security analysis, portfolio management and market analysis.

BA 341-342 **Accounting V and VI** **(3-0) (3-0)6**
[BA 242]

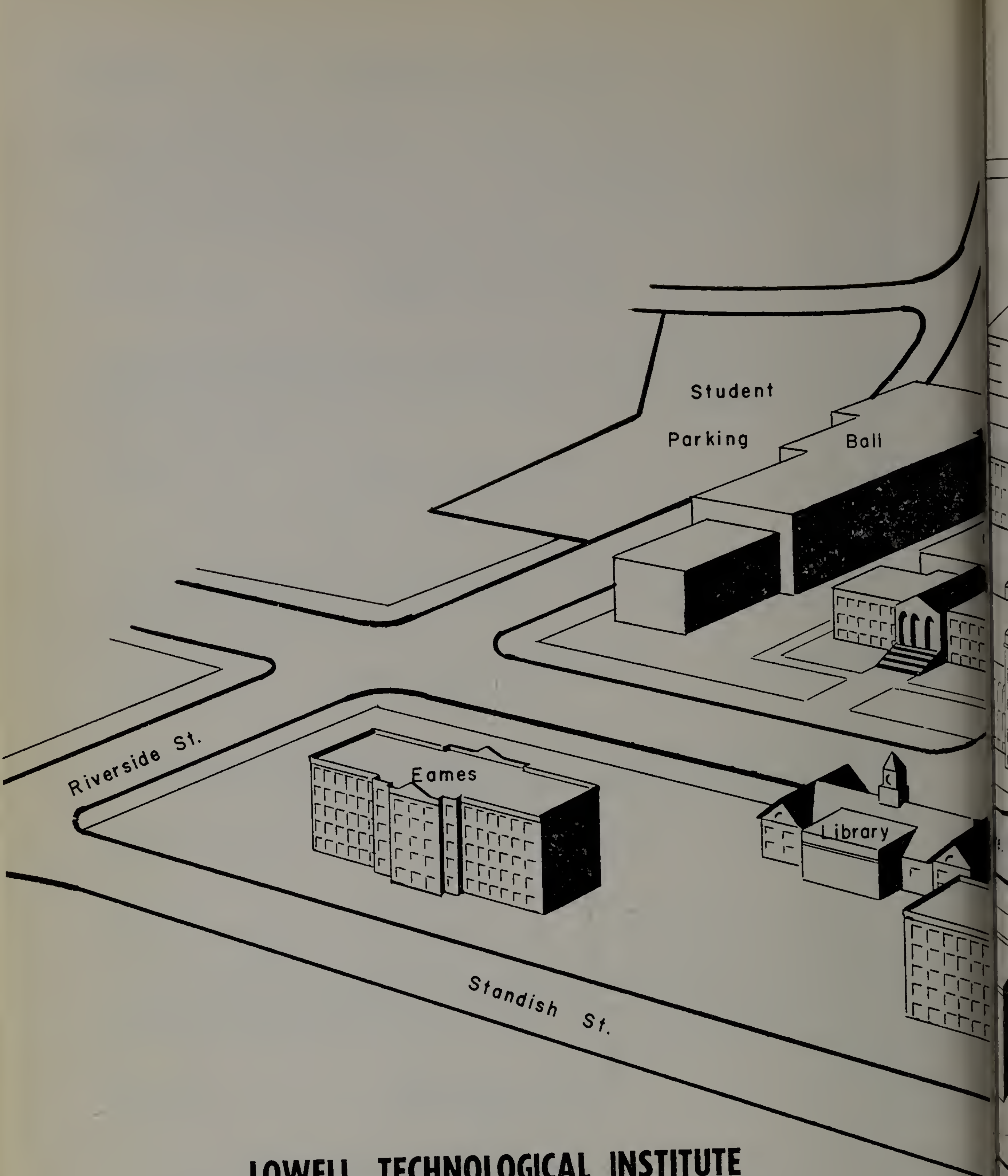
Advanced accounting comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

BA 344 **Cost Accounting** **(3-0)3**
[BA 142]
[For Accounting Majors]

Job lot, process, and standard cost systems, including joint and byproduct problems, and the managerial uses of cost data.

BA 346 **Managerial Accounting** **(2-2)3**
[BA 142]
[For Non-accounting Majors]

The use of cost accounting from the point of view of the



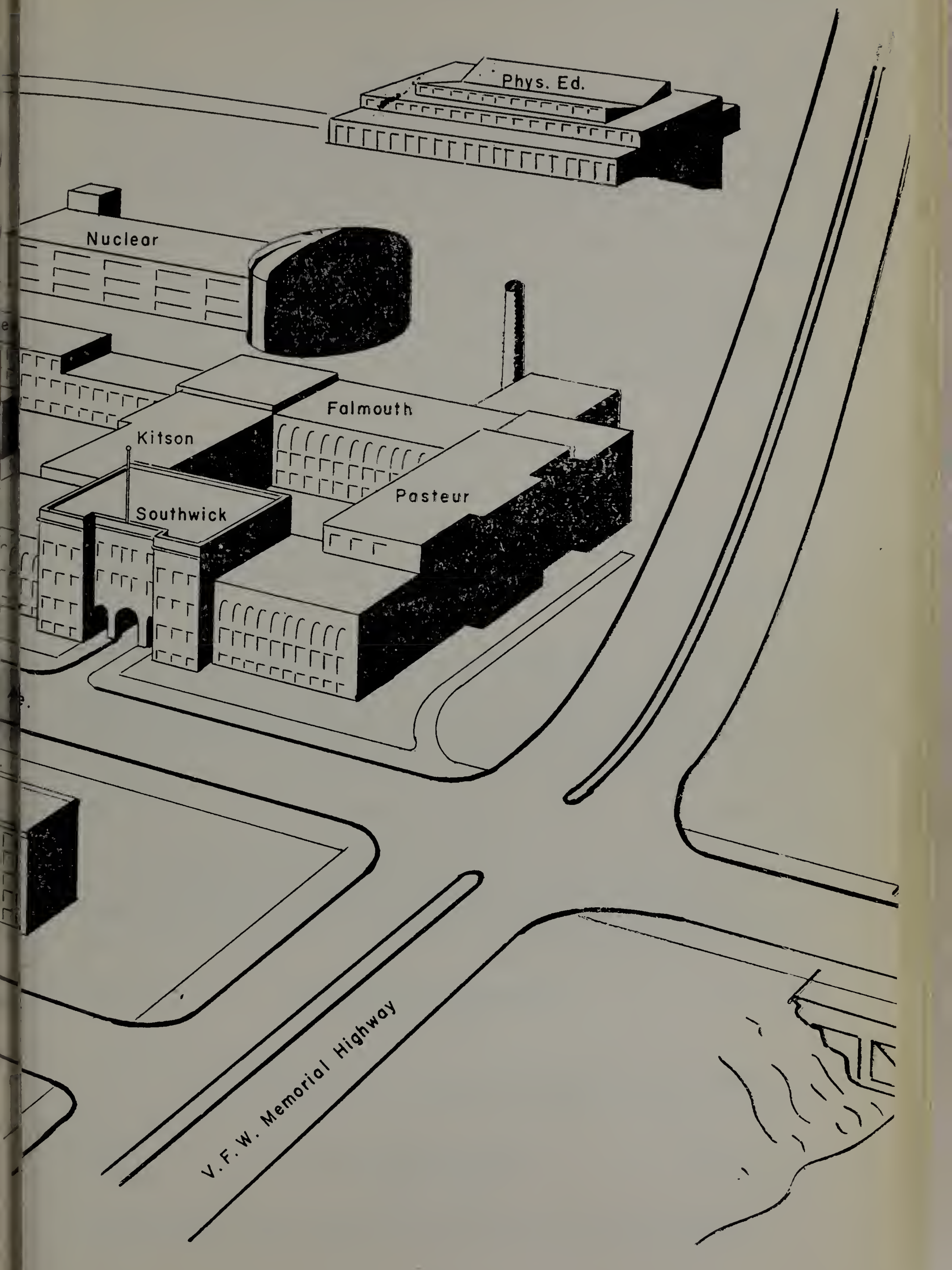
LOWELL TECHNOLOGICAL INSTITUTE
LOWELL MASSACHUSETTS

CLASSROOM DESIGNATION:

LETTER PREFIX REFERS TO BUILDING
FIRST NUMBER INDICATES FLOOR
HENCE, ROOM K-311 IS LOCATED IN KITSON HALL, 3rd FLOOR

BOOKSTORE: SECOND FLOOR, SOUTHWICK HALL.

DIVISION OF EVENING STUDIES OFFICE: BASEMENT, CUMNOCK HALL.


Phys. Ed.
Nuclear
Falmouth
Kitson
Pasteur
Southwick
V.F.W. Memorial Highway

business manager. Job lot, process, and standard cost systems are utilized.

BA 362 Business Law (3-0)3

The principles of commercial law, including contracts, agency, sales, partnerships, corporations, negotiable instruments, bailments and carriers, insurance, personal property, real property, suretyship and guarantees, and bankruptcy.

BA 371-372 Production Management I and II (3-0) (3-0)6

The internal organization and productive process of the manufacturer, including the management functions of planning, directing, and administration in relation to production. Plant layout, materials handling, inventory control, quality control, and time and motion study systems.

BA 402 International Business (3-0)3
[EC 202]

The distinctive features of international commerce, including government policies, multinational corporate problems, foreign exchange, tax problems, and special licensing and agency arrangements.

BA 403 Electronic Data Processing (3-0)3

The role of digital computers in the solution of management problems. The preparation and solution of sample problems on the Institute's computer installation.

BA 421 Procurement (3-0)3
[BA 321]

Purchasing procedure, quality control, inventory control, source selection, forward buying, and speculation, as applied to the individual enterprise.

BA 423 Marketing Management (3-0)3
[BA 321]

Problems of marketing, especially from the point of view of the formulation of business policy.

BA 426 Sales Management (3-0)3
[BA 321]

Management of the selling function in its broad aspect.

Sales organization, compensation, selection, training, and supervision. Market research, product packaging and development, and distribution policies.

BA 431 **Financial Management** **(3-0)3**
[BA 242, BA 331]

Advanced study of financial management principles. Emphasis on problem analysis and problem solving.

BA 441 **Auditing** **(3-0)3**
[BA 342]

Duties and responsibilities of the auditor, kinds of audits, programs of audit, and auditor statements and reports.

BA 444 **Advanced Cost Accounting** **(3-0)3**
[BA 344]

Estimated cost systems, budgeting control with standard costs, and cost and profit analysis for decision-making purposes.

BA 445 **Tax Accounting** **(3-0)3**
[BA 342]

Tax problems of partnerships, corporations, reorganizations, personal holding companies, trusts, gifts, and estates. Problems and interpretations of the internal revenue code and regulations of both the Federal and State agencies.

BA 451 **Personnel Management** **(3-0)3**

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as employee health and safety, welfare, education, and wage and salary administration.

BA 452 **Industrial Relations** **(3-0)3**
[BA 451]

Human interaction and group behavior in organized industrial settings, Interpersonal intergroup conflict, motivation, and leadership.

BA 481 **Insurance** **(3-0)3**

Theory of risk, physical and moral hazards, types of insur-

ance carriers, and basic features of each of the principal kinds of insurance.

BA 492 **Transportation** **(3-0)3**

Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies of the United States.

BA 500 **Research Seminar** **(3-0)3**
[Permission of Department Head]

Designed to give the better Business Administration student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

CIVIL ENGINEERING

CE 201 **Surveying I** **(3-4)4**
[MA 107; ME 104]

Principles of data gathering by surveying processes for the measurement and determination of lengths, directions, coordinates, areas, volumes and topographic information. Illustrative fieldwork to give facility in basic surveying techniques; problems are used to demonstrate processing of field data.

CE 202 **Surveying II** **(3-4)4**
[CE 201]

Application of basic surveying techniques to the solution of engineering problems implicit in such Civil Engineering areas as transportation, industrial and domestic structures, utilities for the safety and convenience of humans, and water supply and control. Fieldwork projects typical of application of surveying to Civil Engineering.

CE 312 **Structures I** **(3-0)3**
[ME 220]

An introduction to the principles of structural analyses and their application to typical Civil Engineering structures. Emphasis will be on the analyses of statically determinated planar structures and statically indeterminate beams.

CE 322 **Hydraulics** **(4-0)4**
[ME 309]

Principles and physical properties of fluids at rest and in motion through open and closed conduits. An introduction to the basic concepts of hydrodynamics and hydraulic similitude.

CE 341 **Transportation** **(3-3)4**
[CE 202]

Development of the basic principles pertaining to the movements of people and materials by modern routes of transportation such as highways, airlines, railways, water routes and pipelines. Areas covered include geometric design, traffic, materials of construction and the basic concepts of transportation economics, finance and administration.

CE 411 **Structures II** **(3-3)4**
[Not offered 1968-69]

CE 412 **Structures III** **(3-3)4**
[Not offered 1968-69]

CE 414 **Concrete** **(3-3)4**
[Not offered 1968-69]

CE 421 **Hydrology** **(3-3)4**
[Not offered 1968-69]

CE 431 **Soil Mechanics I** **(3-0)3**
[Not offered 1968-69]

CE 432 **Soil Mechanics II** **(3-3)4**
[Not offered 1968-69]

CE 491 **Professional Problems** **(3-0)3**
[Not offered 1968-69]

CHEMISTRY

CH 001-002 **Chemical Principles** **(4-0) (4-0)6**

An introduction to the structure and reactivity of chemical species based on the periodic properties of the elements. Physical aspects of chemical theory are stressed and correlated.

CH 003-004 Chemical Principles Laboratory (0-2) (0-2)2

The presentation of chemical principles in the form of concrete examples with illustration of the methods of an experimental science. Emphasis is placed on training in scientific observation, systematic recording of data and the derivation of conclusions from experimental results.

CH 201-202 Organic Chemistry (3-3) (3-3)8
[CH 002]

The classification, nomenclature, structure, mechanism of reaction, and behavior in bulk of important kinds of organic species. The laboratory work illustrates the experimental techniques which can be used to react, purify, characterize, and identify organic substances.

CH 205 or 206 Qualitative Analysis (3-0)3
[CH 002]
[Primarily for students not majoring in chemistry]

A lecture course dealing with the physical chemistry of aqueous electrolytic solutions. The nature and behavior of solutes and solutions; reaction rate theory and its relation to solubility, proton transfer, and other types of equilibria; and application of the above principles to problems of separation and identification.

CH 208 Inorganic Chemistry (3-0)3

The chemical behavior, electronic and geometric structures, methods of preparation, reactions, and nomenclature of some of the more common elements and their compounds as well as some of the better-known transition and inner-transition elements. The laboratory deals with the preparation and study of some of the more interesting compounds.

CH 209 Analytical Techniques (1-3)2
[CH 002]

The fundamentals of analytical techniques, including basic gravimetric and volumetric measurements and their calculations. Primarily for students majoring in Chemical Engineering and Paper Engineering.

CH 210 **Analytical Chemistry** **(3-6)5**
[CH 213]
[Primarily for students majoring in chemistry]

The fundamental principles of analytical chemistry, both qualitative and quantitative, including the separation, identification, and quantitative measurement of substances through chemical methods, chromatography, ion exchange, microscopy, fluorometry, and spectroscopy.

CH 211 or 212 **Quantitative Analysis** **(3-4)4**
[CH 002]
[Primarily for students majoring in Plastics Technology]

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric and volumetric analysis, including some coverage of industrial applications.

CH 213 **Properties of Electrolytic Solutions** **(3-6)5**
[CH 002]
FOR CHEMISTRY MAJORS ONLY.

An introduction to the reactions and phenomena occurring in aqueous electrolytic solutions. Proton transfer, complexation, precipitation and oxixation reduction reactions are studies quantitatively and in detail both from a kinetic and an equilibrium standpoint. Instruction in fundamental analytical techniques is given as a tool for the later laboratory work, which includes conductometric studies, measurements of rate and equilibrium constants, and studies on coordination compunds. Extensive calculations involving all these phenomena are given, as well as those pertaining to the analytical methods.

CH 321 **Organic Chemistry Laboratory II** **(1-6)3**
[CH 202]

A continuation of CH 202 laboratory involving additional laboratory work in organic chemistry with emphasis on modern techniques of synthesis.

CH 331 **Physical Chemistry** **(3-3)4**
[CH 213, MA 205]

Basic physical chemical approaches to studies of gages, laws of thermodynamics, solution properties, chemical and phase equilibria. For chemistry majors only.

CH 332 **Physical Chemistry** **(3-3)4**
[CH 331]

CH 335-336 **Principles of Physical Chemistry** **(3-3) (3-3)8**
[CH 206, MA 205]

Similar to CH 331-332 but designed for students not majoring in chemistry.

CH 342 **Organic Qualitative Analysis** **(1-6)3**
[CH 202]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 403-404 **Chemistry of High Polymers** **(3-4) (3-4)8**
[CH 202, CH 332]

The physical and organic chemistry of monomers and polymers, including a consideration of non-bonding forces, spectroscopic methods of structure determination, structure and property correlations, fractionation, thermodynamics, and methods of molecular weight determination for polymers in solution; the kinetics of condensation and addition polymerization as applied to polymers and copolymers, mechanism of free radical and ionic polymerization, stereo-specific polymers, the chemistry of the more common polymers systems, and preparation of their corresponding monomers.

CH 407-408 **Advanced Studies in Chemistry** **Credits to be arranged**
[Permission of the Chairman of the Chemistry Division and the instructor]

Advanced work in analytical, organic, inorganic, physical, or textile chemistry, including literature survey, laboratory work, and reports.

CH 411 **Advanced Analytical Chemistry** **(2-4)3**
[CH 210, CH 332]

Advanced analytical techniques based on physical-chemical principles and utilizing instrumental methods wher-

ever applicable. The analytical use of complexes, radiant energy methods, electrochemistry, chromatography, polarography, analytical applications of radioisotopes, and physical methods of separation.

CH 423-424 Advanced Organic Chemistry (3-0) (3-0)6
[CH 202]

Extension of first-year organic chemistry to include additional classes of compounds and special topics. Emphasis is placed on synthetic methods, including the mechanism, scope, and limitations of the important name reactions in the field of synthetic organic chemistry.

CH 431-432* Advanced Physical Chemistry (3-0) (3-0)6
[CH 332 or equivalent]

An extension of introductory physical chemistry for undergraduate majors and first-year graduate students in chemistry and related fields, with emphasis on classical and statistical thermodynamics as they apply to the various chemical phenomena.

CH 434* Colloid and Surface Chemistry (3-0)3
[CH 331 or CH 335]

Theory of colloidal systems including physical chemistry of surfaces, electrokinetic phenomena and molecular kinetic and optical properties of colloids. Consideration is also given to thin layers and to foams and emulsions including the preparation of lyophobic colloidal systems, and the stability of lyophobic sols.

CH 443-444 Advanced Inorganic Chemistry (3-0) (3-0)6
[CH 332]

A treatment of the structure and reactions of the inorganic elements and their compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics and the theory of the chemical bond, spectroscopy, inorganic stereochemistry, crystal field theory, reactions in nonaqueous solvents, coordination chemistry, and atomic structure, including the structure of the atomic nucleus.

CH 481* **Radiochemistry** **(3-3)4**
[CH 002, MA 205, PH 205]

Fundamentals of radiochemistry, including radioactivity, atomic nuclei, nuclear reactions, reactors, and radiation detection and measurement, with emphasis on the use of radioactive materials in chemical applications. Designed primarily for majors in chemistry and in allied fields.

CH 484 **Elements of Radiochemistry** **(3-3)4**
[CH 002]

A review of chemical principles as applied to radiochemistry, including coverage of such topics as radioactivity, nuclear reactors, radiation chemistry, use of tracers in chemical application, and separation and study of fission products.

CH 501 **Interpretation of Data** **(3-0)3**

Mathematical methods of analyzing, plotting, and interpreting experimental data. Lectures and exercise.

CH 502 **Absorption Spectrophotometry and Color Measurement** **(2-3)3**

Theory and application of absorption spectrophotometry to the qualitative and quantitative analyses of chemical substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges, including theories of color, vision, and subjective color evaluation.

CH 503-504 **Chemistry of High Polymers** **(3-0) (3-0)6**
[CH 202, CH 332]

An introduction to the physical and organic chemistry of high polymers for graduate students. Similar to CH 403-404 but with additional assigned reading.

CH 505-506 Techniques of Polymer Chemistry (0-4) (0-4)2

A laboratory subject to be taken concurrently with CH 503-504 and designed to acquaint a graduate student majoring in Polymer Science with the techniques used in the preparation, characterization, and investigation of macromolecular substances.

CH 507-508 Chemistry Seminar (1-0) (1-0)2

CH 509-510 Introduction to Polymer Physics (2-0) (2-0)4

Elements of chain statistics, bonding in polymer, segmental and molecular motion, first and second order transitions, rubber elasticity, viscosity, viscoelasticity, mechanics of network response, electrical and optical properties of polymers, crystalline state in polymers.

CH 512 Physical Chemistry of Surface-Active Agents (3-0)3

A series of lectures on the physicochemical principles involved in the use of surface-active agents. The surface and bulk properties of the agents are studied and related to the over-all technical properties and uses.

CH 515 Advanced Laboratory Technique (1-3)2

A study of the theory and application of the more advanced techniques and equipment in the preparation and purification of organic compounds, including high efficiency fractionation, vacuum and molecular distillation, hydrogenation and reactions in inert atmospheres.

CH 516 Chemical Literature (1-0)1

Use of the chemical library, journals, reference works and other technical publications pertaining to chemical subjects. Exercises in finding assembling and using such data.

CH 517 Glass Working (0-1)0

Fundamental techniques in the preparation and assembling of glass apparatus.

CH 521-522 Physical Organic Chemistry (3-0) (3-0)6
[CH 424]

Modern concepts of molecular structure developed and related to the physical and chemical properties of organic compounds. Polarization effects and reaction mechanisms considered in detail.

CH 523 Organic Reaction Mechanisms and Structure (3-0)3

Designed to provide insight into how reactions occur and how the reaction mechanism is studied. Emphasis is placed on

bonding, substitution and elimination processes, stereochemistry, and conformational analysis. For graduate students only.

CH 524 Organic Synthesis (3-0)3

Mechanism, scope, and limitations of important selected types of reactions, and design of synthetic sequences. Emphasis is placed on reduction, oxidation, halogenation, alkylation, and acylation. For graduate students only.

CH 527-528 Stereochemistry (3-0) (3-0)6

The fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.

Offered in alternate years.

CH 531-532 Statistical Mechanics for Chemists (3-0) (3-0)6

[CH 539 or equivalent]

A continuation of the introductory statistical mechanics presented in CH539. Current theories on such topics as configuration of polymer molecules, rubber elasticity, and solution structure, as well as principles of classical statistical mechanics.

CH 533-534 Quantum Mechanics for Chemists (3-0) (3-0)6

[CH 539 or equivalent]

A continuation of the introduction to quantum mechanics in CH 539. Current theories on such topics as quantum mechanical treatment of crystalline solids, imperfect gases and liquids, and electromagnetic susceptibilities.

CH 535-536 Advanced Topics in Physical Chemistry (3-0) (3-0)6

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 537 Chemical Thermodynamics (3-0)3

[CH 539 or equivalent]

An advanced subject in chemical thermodynamics, with emphasis on the recent mathematical developments in the description of chemical systems and with attention given to

current experimental methods of obtaining thermodynamic data. The chemical and physical scientific literature is used extensively.

CH 538 Rhelogy (3-0)3

The general principles of the deformation and flow of matter under stresses studied qualitatively and quantitatively. Hookean and non-Hookean elasticity and Newtonian and non-Newtonian flow related to the properties of materials, especially in the field of high polymers.

CH 539 Theoretical Chemistry (3-0)3
[CH 443-444 or equivalent]

The formal and group theoretical aspects of quantum chemistry particularly as they apply to molecular structure and reactivity.

CH 540 Chemical Kinetics (3-0)3
[CH 432 or equivalent]

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanism, collision theory, and absolute rate theory.

CH 541-542 Graduate Thesis Credits to be arranged

An independent investigation of a problem by the student in conference with a faculty adviser and approved by the Department Head. A clear and systematic written presentation of the results is required.

CH 543-544 Modern Inorganic Chemistry (3-0) (3-0)6

Similar to CH 443-444 but designed specifically for graduate students. Emphasis is placed on the theory of the chemical bond, bonding in complexes, coordination theory, spectroscopic methods, non-aqueous solvent systems.

CH 549 Physical Chemistry of Macromolecules I. Theory. (3-0)3

An advanced treatment of physical chemistry of macromolecules including chain statistics, thermodynamics, hydro-

dynamic and optical properties of solutions of polymers and polyelectrolytes.

(Offered Semester I, 1968-1969)

CH 551
Physical Chemistry of Macromolecules II. Methods. (3-0)3
[CH 549]

An advanced treatment of various experimental methods involved in the determination of structural parameters of macromolecules. The treatment includes among others viscometry, light scattering, thermal diffusion, ultracentrigugation, streaming birefringence and methods based on transport phenomena in the presence of electric field.

(Offered Semester I 1969-1970)

CH 553 Organic Chemistry of Macromolecules (3-0)3
[CH 403, CH 424]

An advanced study in polymer science concerned with modern theoretical concepts and including mechanisms of formation and degradation of macromolecules.

Offered in alternate years.

CH 554 Stereochemistry of Macromolecules (3-0)3
[CH 404, CH 424]

Stereochemical factors affecting the formation and properties of macromolecules.

Offered in alternate years.

CH 561-562 Advanced Organic Synthesis (3-0) (3-0)6
[CH 523-524 or equivalent]

The application of known organic reactions to the synthesis of chemical species in such fields as the terpenes, steroids, alkaloids, antibiotics, and selected heterocyclic derivatives.

Offered in alternate years.

CH 564 Organic Qualitative Analysis (1-6)3

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds. Offered in alternate years.

CH 568 Structural Analysis (3-0)3

Practical application of instrumental data in the determination of the structure of organic compounds. Includes mass spectroscopy, ultraviolet spectroscopy, infrared spectroscopy, nuclear magnetic resonance spectroscopy, and optical methods.

CHEMICAL ENGINEERING

CN 203 Introduction to Chemical Engineering (3-0)3
[CH 002, MA 108]

Introduction to the fundamentals of chemical engineering. Curve plotting, elements of kinetics and chemical equilibria, development of flow sheets, and introduction to mass balances. Analysis of two chemical processes.

CN 204 Industrial Stoichiometry (3-0)3
[CN 203, MA 206 taken concurrently]

Mass and energy balances, including phase separation and thermochemistry. Applications to chemical engineering processes. Development of unsteady-state concepts.

CN 303 Chemical Engineering I (3-0)3
[CN 204]

The Unit Operations concept. Study of Fluid Flow and Heat Transfer and evaporation.

CN 304 Chemical Engineering II (3-0)3
[CN 303]

Mass Transfer Operations of Absorption and Extraction, Distillation, Humidification and Drying.

CN 311 Chemical Engineering Thermodynamics (3-0)3
[CN 303 taken concurrently]

Application of the first and second laws of thermodynamics to chemical engineering problems. Heats of reaction and

enthalpy changes as a function of temperature; fugacity and activity; state properties; homogeneous and heterogeneous equilibria; electrochemical effects.

CN 313 or 314 Industrial Instrumentation (3-0)3
[CN 204]

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level and fluid flow; response characteristics of mechanical, electrical and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; close-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

CN 403 Reactor Design and Kinetics (3-0)3
[CN 304]

Review of principles underlying rates of transformation of matter and energy; effect of temperature and catalysis on chemical reactions; application to design of chemical reactors.

CN 407 Engineering Analysis of Chemical Processes (3-0)3
[CN 304]

A qualitative and quantitative analysis of selected chemical processes from a chemical engineering and economic standpoint. Reports and plant visits.

CN 408 Engineering Materials (3-0)3
[Approval of instructor]

Study of materials for engineering and construction purposes from the standpoint of physical and chemical structures, corrosion, economics and end use requirements. Corrosion principles, structures of metals, polymeric materials and non-metallic inorganic materials.

CN 410 Process Analysis and Plant Design (3-0)3
[CN 304]

Economic principles applied to evaluation and optimization of various chemical engineering processes. Several minor projects and one major design problem requiring written reports and oral presentation. Use of computers in design computations.

CN 411-412 Unit Operations Laboratory (0-6) (0-6)4
[CN 304]

Experimental projects involving various unit operations. Both group and individual projects. Written and oral reports and required. Possibility of individual original research for selected students.

CN 501-502 Graduate Thesis Credits to be arranged

Every graduate student is required to write a thesis on original research work done under the supervision of a senior staff member. This thesis must be approved by an examining committee appointed by the Department Head.

CN 503 or 504 Absorption and Extraction (3-0)3
[CN 304]

Principles of separation; phase diagrams and multicomponent mixtures; mathematics and graphical solutions to mass transfer problems.

CN 505 or 506 Colloid Chemistry for Chemical Engineers (3-0)3
[CN 304]

Colloid chemistry principles applied to chemical engineering process problems; zeta potential and its applications; specific problems involving surface chemistry and physics.

CN 507 or 508 Corrosion and Electrochemical Principles (3-0)2
[Approval of instructor]

Electrochemical principles and physical chemistry relating to the corrosion of metals. Materials of construction and design based on these principles.

CN 509 Mathematics for Chemical Engineers (3-2)4
[CN 403, CN 410]

Applications of mathematics to chemical engineering problems; unsteady state equations and problems; special graphical solutions; use of computer for solution of complicated problems; specific real engineering problems.

CN 511 or 512 Structure and Properties of Matter (3-0)3

Fundamental properties of matter as they relate to chemical engineering problems. Materials of construction. Rheological properties of polymeric materials and their application to chemical engineering.

CN 514 Advanced Economic Balance (3-2)4
[CN 410]

Detailed study of several processes from the standpoint of optimization and economics of design. Group design of a specific chemical plant. Use of computers in solutions of design problems.

CN 517 or 518 Advanced Distillation (3-0)3
[CN 503 or 504]

Review of principles of mass separation; applications to multicomponent distillation. Design of columns and analysis of specific systems.

CN 523 or 524 Advanced Chemical Process Analysis (3-0)3
[CN 407]

Detailed study of several commercial processes from the standpoint of engineering principles and economics. Economics and interrelationships of the chemical industry. Analysis of specific real problems. Factors involved in determination of best design from several alternatives.

CN 525 or 526 Advanced Heat Transfer (3-0)3
[CN 304]

Review of principles of energy transport. Specific problems in convection and radiant heat transfer. Mathematical treatment of unsteady-state heat transfer.

CN 530-531 Chemical Engineering Seminar (1-0) (1-0)1

Required of all graduate students.

CN 532 or 533 **Applications of Computers** **(2-3)3**
[Approval of Instructor]

Use of computers in the handling of engineering data. Development of techniques used in optimization problems and in plant design. Analysis of when and where to use computers in efficient solution of engineering problems.

CN 534 or 535 **Special Chemical Engineering Projects** **Credits to be arranged**
[Approval of Instructor]

Special projects laboratory undertaken by a student to expand his knowledge in specific fields not necessarily related to his thesis. Content of project and hours assigned must be approved by Department Head.

ECONOMICS

EC 201 **Economics I** **(3-0)3**

The foundations and nature of economic principles. National income, money and banking, and monetary and fiscal policy.

EC 202 **Economics II** **(3-0)3**
[EC 201]

Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 211-212 **Economic Statistics I and II** **(3-0) (3-0)6**

Topics covered include measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 Economic Development of the United States (3-0)3

A study of the influence of science and technology upon the economic development of the United States.

EC 302 **Labor Economics** **(3-0)3**
[EC 202]

The effect of American capitalism on the position of labor. The rise of union organization and the factors in its growth. Trends in the labor force, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 **Microeconomic Theory** **(3-0)3**
[EC 202]

An advanced examination of price and production theory, the theory of the household and the firm.

EC 304 **Macroeconomic Theory** **(3-0)3**
[EC 202]

An analysis of Keynesian and post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 402 **Government and Business** **(3-0)3**
[EC 202]

An examination of federal, local and state controls on business activity, with emphasis on the economic interpretation of the various statutes and court decisions involving business.

EC 403 **International Trade Theory** **(3-0)3**
[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 404 **Comparative Economic Systems** **(3-0)3**
[EC 202]

Income distribution and resource allocation in centrally-planned as opposed to market-oriented economics. Emphasis on output decisions, role of price, problems of consistency and efficiency, success indicators, and incentives.

EC 407 **Econometrics** **(3-0)3**
[EC 212, 304]

The course will provide the student both theoretical and

empirical knowledge of econometrics. Methods of handling data, quantative empirical estimates, and tests of economic theory.

EC 408 History of Economic Thought (3-0)3
[EC 303]

Analysis of the development of economic theory; emphasis on the rise of classical economic thought.

EC 409 National Income and Business Cycles (3-0)3
[EC 202]

Analysis of the relationship between national income, total spending and the price level. The nature and cause of changes in the level of business activity. Business cycle theories, forecasting and the problems of instability.

EC 410 Economic Development of Less Developed Countries (3-0)3
[EC 202]

The role of capital (private and social), technology, labor, government, international trade, socio-cultural and institutional factors in development. Analysis of capital/output ratios, social marginal product, disguised unemployment and overpopulation theories. Critical analysis of development strategies.

EC 411 Public Finance (3-0)3
[EC 202, BA 332]

Study of alternative methods of financing non-market enterprises. Special emphasis on the tax and expenditure policies of federal, state and local governments.

EC 412 Managerial Economics (3-0)3
[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis and competitive action.

EC 414 Engineering Economy (3-0)3
[EC 202]

The significance of the economic aspects of engineering.

The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

EC 500 Research Seminar (3-0)3
[Permission of Department Head]

An honors course to permit the advanced student to do research in topics of special interest in economics under faculty supervision.

ELECTRICAL ENGINEERING

EE 201-202 Introductory Circuit Theory (4-0) (4-0)8
[MA 108, PH 104]

An introduction to the study of the mathematical and physical aspects of electrical circuits in which radiation in the form of electromagnetic waves does not play a major role. Kirchhoff's laws, Thevenin's theorem, reciprocity, and other network theorems, funicular diagrams, complex algebra, coupled circuits, sinusoidal steady-state and transient behavior are discussed.

EE 205-206 Basic Electrical Engineer Laboratory (0-3/2) (0-3/2)1
[EE 201 taken concurrently]

Experimental work designed to acquaint the student with electrical instruments and the techniques of electrical measurements and to provide experimental verification of the behavior of passive electrical circuits.

EE 211 Fundamentals of Electricity (3-0)3

An introduction to electric circuits for students not majoring in Electrical Engineering but who have a background in basic principles of electricity and magnetism. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state a.c. circuits, two-terminal networks, and two-terminal-pair networks.

EE 212 Introductory Electronics (3-0)3
[EE 211]

A background subject in electronics for students not majoring in Electrical Engineering, presenting the properties and uses of vacuum tube and semiconductor devices.

EE 214 Electrical Machinery Laboratory (0-3)1
[EE 211]
[Not open to students majoring in Electrical Engineering]

An introductory laboratory course primarily devoted to the measurement of terminal characteristics of electrical machinery.

EE 301-302 Electronic Devices/Models (4-0) (4-0)8
[EE 202]

Basic concepts, techniques, and methods of analysis of electronic devices, with particular emphasis on the break-point method, piecewise linerization, and active circuit theory. Diode operation, rectification, amplification, and RC/RL waveshaping. Single-stage, multistage, power, and tuned amplifiers are discussed with consideration of gain, bandwidth, and frequency response.

EE 306 Electromagnetic Theory (4-0)4
[MA 313]

Electricity and magnetism presented from the field theory point of view, using vector analysis and Maxwell's equations. The static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials; time-changing electric and magnetic fields, magnetic induction, electromagnetic waves and energy flow, and boundary value problems.

EE 309-310 Electronic Devices Laboratory (0-3) (0-3)2
[EE 206; EE 301-302 taken concurrently]

An intermediate laboratory course in which the experiments are designed to stimulate an appreciation for the limitations of basic electronic equipment. The experiments are closely coordinated with allied courses and provide experimental verification of the properties of electronic devices and circuits.

EE 315 Network Analysis (4-0)4
[EE 202, MA 206]

Complete solutions of linear passive networks; power and energy associated with arbitary excitation functions; Fourier and Laplace transformations and a comparison of network analysis by these methods with the classical differential equa-

tion approach; numerical evaluation methods using impulse train techniques; and convolution in the time and frequency domain. Selected topics from the theory of determinants, matrices, linear transformations and quadratic forms and functions of a complex variable emphasizing the basic aspects for analysis problems.

EE 317 Digital Computers Applications and Programming (2-2)4

The physical principles and instrumentation of digital computers and their application to problems in science and engineering. Programming methods and techniques.

EE 323 Electrical Energy Conversion (3-2)4
[EE 211, MA 205]

The generation, control, utilization and conversion of electrical energy.

EE 351 Industrial Electronics (3-0)3
[Not open to students majoring in Electrical Engineering, Mechanical Engineering, Physics, or Textile Engineering]

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum and gaseous-tube characteristics and of circuits containing such tubes for the purpose of rectification, amplification and oscillation; and industrial photoelectric and time delay relays.

EE 355 Electrical Controls and Power Circuits (2-1)3
[Not open to students majoring in Electrical Engineering]

Power requirements in single-phase and three-phase power circuits; operating characteristics of various types of direct-current and alternating-current motors and generators; manual and automatic electric controls including photoelectric relays, time delay relays, and motor control. Laboratory workshop.

EE 401-402 Feedback Control Systems and Their Components (3-0) (3-0)6
[EE 315]

The various methods of analysis and design of feedback control systems, including the time-domain, frequency-domain, and root-locus approaches. Some coverage of control system components is included.

EE 403-404 Microwave Electronics (3-0) (3-0)6
[EE 306]

Elements of electromagnetic theory, transmission lines, inpedance matching, waveguides, generation and focusing of high-current electron beams with electric and magnetic fields, electron optics, velocity modulation, space charge wave propagation and traveling wave interaction with electron beams with application to microwave amplifiers and oscillators, and antennas.

EE 409-410 Applied Electronics Laboratory (0-4) (0-4)4
[EE 310]

The purpose of this laboratory is to give the student an experimental familiarity with the nature, application and performance of various electronic devices. Emphasis is given to methods of electrical measurement and the preparation of technical reports.

EE 411-412 Logical Design of Digital Computers (3-0) (3-0)6
[EE 301 or Permission of Instructor]

Foundations for the complete design of digital computer subsystems, such as the arithmetic unit, computer memory, control, and input-output equipment with emphasis on basic circuity as well as the logical tools: flip-flops, shift-registers, logical gates, add magnetic core memories. Boolean algebra, system synthesis, coding, and error detection.

EE 415-416 Electronic Amplifier Circuits (3-0) (3-0)6
[EE 302, EE 315]

An integrated treatment of the analysis and design of vacuum tube and transistor amplifier circuits with emphasis on the design of such circuits. The majority of circuits considered are of the small-signal catergory, i.e., Class A operation.

EE 423 Analog Computer Technology (1 1/2-1 1/2)3
[EE 315]

Logical structure of analog computers; methods of problem preparation; study of computer components, input and output devices, lectures and laboratory workshop.

EE 425-426 Wave Shaping and Generation (3-0) (3-0)6
[EE 302]

Principles and methods of wave shaping and wave genera-

tion using active and passive elements. Timing, switching, memory devices, oscillation, and wave shaping. Free use is made of piecewise-linear approximation, the break-point method, and/or the assumed diode state in conjuction with linear network theory. Particular emphasis is given to model representation and its analysis.

EE 429 Network Synthesis (3-0)3
[EE 315, MA 313]

A review of methods of analysis useful in the study of signals; systems and their response; impedance and admittance properties relating the frequency and time domain aspects of physical circuit behavior; linear passive network theory, emphasizing the synthesis aspects; fundamental works of Foster Cauer, Brune, Darlington, and Guillemin applied to the design of networks having a prescribed driving-point and transfer characteristics.

EE 431-432 Special Topics in Electronics (3-0) (3-0)6
[Permission of Instructor]

An analytic consideration of one or more special topics selected from recent developments in the field of electronics.

EE 433-434 Electro-Optical Analogues (3-0) (3-0)6
[EE 302, EE 315, MA 313]

A review of linear system analysis, including Fourier analysis, as applied to the analysis of linear electrical and optical systems, with emphasis on the similarities of the two classes of systems.

EE 437-437 Introduction to Optical Information Processing (3-0) (3-0)6
[EE 306, EE 315]

Principles of optical propagation as described by the Fresnel-Kirchhoff Integral and the Rayleigh Integral, concept of transform theory as applied to optical imaging systems, transform theory of conjugate focal plane of lenses in coherent optical systems, geometrical optics as described by Newtonian lens formulae and principles of holographic three-dimensional wavefront reconstruction.

EE 441-442 Systems Engineering (3-0) (3-0)6
[Permission of Instructor]

Basic problems in communications systems, including AM, FM, PCM, radio and microwave transmission. The system viewpoint is emphasized.

EE 445-446 Analog and Digital Devices and Techniques (3-0) (3-0)6
[For EE 445: EE 301]
[For EE 446: EE 445 or Permission of Instructor]

A survey of analog and digital devices and techniques. Primary emphasis in on general techniques although conventional analog and digital computers are discussed extensively as examples of the application of the techniques. Operational amplifiers, multipliers, amplitude and time scaling, machine organization, number systems, Boolean algebra, arithmetic operations, memory devices, analog to digital conversion, and digital to analog conversion are discussed.

EE 447-448 Communications Theory (3-0) (3-0)6
[Permission of Instructors]

A discussion of statistical communications problems. Particular topics include signal theory, Fourier analysis, power spectrum and correlation functions, sampling theorem and introduction to probability theory. Statistical properties and measures of information, channel capacity and fundamental coding theorems are also discussed.

EE 450-451 Teaching Electrical Engineering (3-0) (3-0)6
[Permission of Instructor]

For qualified high standing students interested in teaching as a career. Laboratory, tutorial, or classroom teaching under the supervision of a faculty member. Students selected by interview. Total enrollment limited by the availability of suitable teaching assignments.

EE 501-502 Applied Statistics (3-0) (3-0)6
[Permission of Instructor]

Consideration of electromagnetic waves in physical media by statistical analysis methods.

EE 503-504 Solid-State Physical Electronics (3-0) (3-0)6
[Permission of Instructor]

A physical interpretation of the properties of materials in terms of their dielectric constant, magnetic permeability, and electrical conductivity; dielectric, ferroelectric, and piezoelectric materials; diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic materials; metals, semicon-

ductors, and insulators; and applications to electrical engineering devices.

EE 505-506 Microwave Electronics (3-0) (3-0)6
[Permission of Instructor]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and traveling wave tubes.

EE 507 Electromagnetics (3-0)3
[EE 306]

The following topics of EE 306 will be explored in greater depth: Laplace's and Poisson's equations in cylindrical and spherical coordinates, Green's function and conformal mapping. In addition a consideration of the following will be made: antennas, propulsion in space, magneto-hydrodynamic waves, and coherence theory.

EE 509 Systems Analysis-Transformation (3-0)3
[Permission of Instructor]

Theory of functions of a complex variable. Applications of transform calculus to the solution of differential equations which arise in the treatment of mechanical, acoustical, thermal and electrical systems.

EE 510 Systems Analysis-State Variables (3-0)3
[MA 533 or Permission of Instructor]

State variable formulation and solution of differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems with consideration of canonical forms for computer simulation.

EE 511-512 Dynamic Control Analysis (3-0) (3-0)6
[Permission of Instructor]

The principles of electronic devices used for control and measurement in applied science and engineering.

EE 521 Automata Studies (3-0)3
[Permission of Instructor]

Mathematical foundation of automata, including probabilistic logics, neuron analogs, Turing machines, and learning theory.

EE 529-530 Network Synthesis (3-0) (3-0)6
[Permission of Instructor]

The formulation of the fundamentals of network theory; establishing realizability conditions and synthesis techniques for various classes of networks and network functions; and methods for realizing one or more networks whenever a function of the given class is prescribed.

EE 531-532 Seminar in Electronics (1-0) (1-0)2
[Permission of Instructor]

Discussion by staff members and students of current technical publications and topics of current interest in electronic science, electronic engineering, and related areas of applied physics.

EE 533-534 Special Problems in Electronics Credits to be arranged

An opportunity for individual study, under the direction of a staff member, of topics in or related to electronic engineering.

EE 535-536 Graduate Research Credits to be arranged

Supervised research and thesis on some problem in electronic science, electronic engineering, or certain areas of applied physics.

EE 547 Statistical Communication Theory (3-0)3
[MA 484 or Permission of Instructor]

A study of statistical communication problems. Particular topics include the description of signals and noise as stochastic processes, optimum smoothing and prediction and statistical decision theory.

EE 548 Information Theory (3-0)3
[MA 484 or Permission of Instructor]

A study of the probabilistic measure of information transmitted by information sources, the determination of the information handling capacity of communication channels and fundamental coding theorems.

INDUSTRIAL MANAGEMENT

IM 351 Motion and Time Study (0-1)1

The application of methods improvement and work measurement techniques. The use of the stop watch, work sampling, and operator charts in terms of application to standard systems such as M.T.M. and Work Factor.

IM 371 Operations Research (3-0)3

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 483 Statistical Quality Control (3-0)3
[MA 383 or 384 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 494 Computer Management (3-0)3

The use of computers in management decision making. Programming of work on the Institute's computer installation.

IM 500 Research Seminar (3-0)3
[Permission of Department Head]

An opportunity for the advanced Industrial Management student to do research in an area of special interest under the direction of a member of the department.

LANGUAGES AND LITERATURE

LL 109-110 English for International Students (3-0) (3-0)6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 English I and II (3-0) (3-0)6

Introduction to literature through the essay, non-dramatic prose fiction, poetry, and drama. Critical papers.

LL 209 Technical and Scientific Communication (3-0)3
[LL 111-112]

Training in the theory, design, and organization of reports in science and industry. Preparation of written and oral reports for specific scientific and technical problems.

LL 213 Introduction to English Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English Literature to 1798.

LL 214 Introduction to American Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature from 1865.

LL 215 Introduction to American Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature to 1865.

LL 216 Introduction to English Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English literature from 1798.

LL 233 Comparative Literature (3-0)3
[LL 111-112]

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 or 235 **Shakespeare** **(3-0)3**
[LL 111-112]

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 259-260 **Elementary German** **(3-0) (3-0)6**

Fundamentals of grammar and basic vocabulary. Audio-lingual emphasis in developing proficiency in speaking, comprehension and reading. Tapes available for laboratory use. No credit for the first semester without the second.

LL 262-262 **Elementary Scientific German** **(3-0) (3-0)6**

Introductory course designed for students who wish to acquire facility in translating scientific material from German to English. Introduction to fundamentals of grammar, problems of syntax and idiom, with emphasis on scientific terminology. No credit for the first semester without the second.

LL 263-264 **Elementary French** **(3-0) (3-0)6**

An introduction to the study of the French language to develop a reading knowledge. Limited practice in pronunciation and writing. No credit for the first semester without the second. For students who have had less than two years of secondary school training in French.

LL 265-266 **Elementary Russian** **(3-0) (3-0)6**

An introduction to the study of the Russian language for students who have not previously studied Russian, or for those who have studied it for not more than one year at the secondary level. Emphasis on basic grammar and on understanding both written and spoken Russian. Tapes available for laboratory use. No credit for the first semester without the second.

LL 267-268 **Elementary Spanish** **(3-0) (3-0)6**

An introduction to the language for those who have not previously studied Spanish or who have not had more than one year of the language at the secondary level. Emphasis on the language as heard and spoken, as the first step in developing

skills in reading and writing. No credit for the first semester without the second.

LL 269-270 Elementary Modern Greek (3-0) (3-0)6

The fundamentals of the language will be studied with emphasis on vocabulary, reading, and writing. Stress will also be given to oral expression. No credit for the second semester without the first semester or its equivalent.

LL 311 Advanced Composition (3-0)3
[LL 111-112]

An intensive course in the rhetorical modes of exposition, with emphasis on argumentation. Students will present and defend papers every two weeks.

LL 313 Introduction to Continental Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers through the Renaissance.

LL 314 Continental Literature Since the Renaissance (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers of the Neoclassic through the modern period.

LL 316 The English Bible as Literature (3-0)3
[LL 111-112]

The several main genres of Biblical literature considered as literature.

LL 333 or 334 Problems of Philosophy (3-0)3

An introduction to some of the persistent problems of ethics and metaphysics and the solutions offered by modern thinkers.

LL 341 or 342 Satire (3-0)3
[LL 111-112]

A study of a literary genre. Selected readings from Horace and Juvenal through Orwell and Burgess.

LL 344 **Modern Poetry** **(3-0)3**
[LL 111-112]

An inductive investigation into the trends of modern American and British poetry, with emphasis on Hopkins, Yeats, Frost, Eliot, Stevens, and Williams.

LL 345 **Modern Irish Literature** **(3-0)3**
[LL 111-112]

Irish writing from 1890 to the present, with special emphasis on the works of Yeats, Synge, O'Casey, Joyce, O'Connor, and O'Faolain.

LL 363-364 **Intermediate French** **(3-0) (3-0)6**
[LL 264 or equivalent]

An intensified study of the language through continued acquisition of audio-lingual skills with emphasis on improving reading and writing. Use of language tapes, records, newspapers, magazines and other media. French will be the language of the classroom, as far as student ability will permit. No credit for the first semester without the second.

LL 365-366 **Intermediate Literary and Conversational Russian** **(3-0) (3-0)6**
[LL 266 or equivalent]

An intensified study of the language, with increased opportunity for speaking and writing the language. Russian short stories, essays and other written material will be supplemented by language tapes and records. No credit for the first semester without the second.

LL 367-368 **Intermediate German** **(3-0) (3-0)6**
[LL 262 or equivalent]

Practice in oral and written expression with emphasis on idomatic expression, training in syntax, and composition. Second term devoted to selected reading and discussion of significant works in prose and lyric poetry to acquaint the student with outstanding authors, ideas, and movements in German literature. Tapes available for laboratory use. No credit for the first semester without the second.

LL 369-370 **Intermediate Spanish** **(3-0) (3-0)6**
[LL 268 or equivalent]

Intensified study of the language, with increased opportun-

ity for speaking and writing. Frequent opportunity for oral presentation in small groups. Readings will include contemporary writings as well as selected masterpieces of Spanish literature. Tapes and records for laboratory use. Spanish will be the language of the classroom insofar as student ability permits. No credit for the first semester without the second.

***LL 435 English Literature of the Eighteenth Century (3-0)3**
[LL 111-112]

A survey of the prose and verse (excluding drama and the novel), with emphasis on the relationship between the literature and the intellectural background.

LL 436 English Romantic Poets (3-0)3
[LL 111-112]

A close study of Wordsworth, Coleridge, Byron, Shelley, and Keats. Attention will be centered on the ways each of these poets articulates characteristically Romantic ideas.

***LL 437 English Literature of the Victorian Period (3-0)3**
[LL 111-112]

Consideration of selected peotry and prose of the Victorian age. Readings, lectures, and discussion.

LL 467 or 468 Seminar in German Masterpieces (3-0)3

Selected reading in German Literature from the seventeenth to the twentieth century. Discussion and analysis of significant German novels, novellen, drama, and lyric poetry. May be taken only upon recommendation of the instructor.

LL 471 The Modern American Novel (3-0)3
[LL 111-112]

A consideration of the outstanding American novelists from 1920'on. Selected works of Faulkner, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3
[LL 111-112]

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 **World Drama** (3-0)3
[LL 111-112]

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 **Modern Drama** (3-0)3
[LL 111-112]

An analysis of major forces in drama from the time of Ibsen to present. Selected representative plays are read and discussed.

LL 476 **Nineteenth-Century British Novel** (3-0)3
[LL 111-112]

The dominant literary form of the period studies in a representative novel of each of the major novelists from Scott to Eliot, including Austen, Dickens, Thackeray and Emily Bronte.

LL 482 **The American Short Story** (3-0)3
[LL 111-112]

A critical survey of the growth and development of the American short story. Consideration of the works of Poe, Crane, Anderson, and others.

LL 495 or 496 **Reading and Research** (3-0)3
[LL 111-112]

Independent study under the guidance of individual members of the department. Consideration for admission limited to Juniors and Seniors with "B" average.

MATHEMATICS

MA 101 **Mathematical Analysis I** (3-0)3

Review of algebra, factoring, rectangular coordinates, functions and graphs, linear equations, exponents and radicals, quadratic equations, inequalities, variation, mathematical induction, progressions, approximate numbers, logarithms, mathematics of investment, trigonometric functions of acute angles, solution of right triangles, and logarithmic solution of right triangles.

MA 102 **Mathematical Analysis II** **(3-0)3**
[MA 101]

Trigonometric functions of any angle, solution of oblique triangles, trigonometric formulas and identities, radian measure, trigonometric curves, trigonometric equations, complex numbers, polynomials, equation and locus, straight line, circle, parabola, ellipse, hyperbola, curve sketching, parametric equations, curve fitting, permutations and combinations, probability and determinants.

MA 107 **Calculus and Analytic Geometry** **(4-0)4**

Functions and graphs, equations of straight lines, the differentiation and integration of algebraic functions together with applications involving related rates, differentials, maxima and minima, Mean Value Theorem, areas, volumes, lengths of curves, areas of surfaces of revolution, center of mass, the theorems of Pappus, pressure, and work.

MA 108 **Calculus and Analytic Geometry** **(4-0)4**
[MA 107]

The differentiation of exponential, logarithmic, and trigonometric functions; integration by parts, integration by partial fractions, integration by trigonometric substitution, and other integral forms; determinants, both second and higher order; properties of roots of higher-degree equations; the conics; translation and rotation of curves, hyperbolic and inverse hyperbolic functions, polar coordinates, parametric equations, differentiation of vectors, and tangential and normal components of velocity and acceleration.

MA 201 **Mathematical Analysis III** **(3-0)3**
[MA 102]

Sets, set operations, logical statements, Boolean algebra, decision making bodies, binary arithmetic, digital computers (design and operation), functions and managerial planning, functions and their use in economics and business, and mathematics of investment and finance.

MA 202 **Mathematical Analysis IV** **(3-0)3**
[MA 201]

Linear programming with graphs and ordinary algebra, vector algebra and matrix algebra used in linear programming,

simplex method, transportation method, differential calculus, limit concept and continuity of a function, integral calculus and applications of calculus in business operations.

MA 205 Calculus and Analytic Geometry (4-0)4
[MA 108]

The scalar and vector products of two or more vectors, solid analytic geometry, space curves, curvature, arc length, partial differentiation, directional derivatives, gradient, chain rule, total differential, the method of least squares, maxima and minima of independent variables, line integrals, multiple integration, and three-coordinate systems; series, including Maclaurin, Taylor, and Fourier series, indeterminate forms, and test for convergence; and complex functions including the Argand diagram, DeMoivre's theorem, the Cauchy-Riemann equations, and logarithmic functions.

MA 206 Differential Equations (3-0)3
[MA 205]

The solution of ordinary differential equations and of partial differential equations of the first order and first degree and of forms in certain other orders and other degrees that lend themselves readily to solution. Practical applications to chemistry and engineering.

MA 221-222 Linear Algebra (3-0) (3-0)6

Basic properties of the real and complex number systems. Introduction to groups, rings, fields. Linear transformations and matrices in finite dimensional vector spaces. Inner products. Applications to geometry.

M A 301-302 Advanced Calculus for Applications (3-0) (3-0)6
[MA 206]

Ordinary differential equations, the Laplace transformation, numerical methods of solving differential equations, series, solutions of differential equations, boundary value problems and orthogonal functions, vector analysis, topics in higher-dimensional calculus, partial differential equations, partial differential equations of mathematical physics, and complex variable theory.

MA 307-308 **Advanced Calculus** **(3-0) (3-0)6**
[MA 206]

Functions of one and several real variables. Metric Spaces. Basic theorems of analysis. Calculus of vectors and differential forms.

MA 313 **Engineering Mathematics** **(4-0)4**
[MA 206]
[For students majoring in Electrical Engineering]

Vector analysis and complex variables with emphasis on applications in Electrical Engineering.

MA 321 **Modern Algebra** **(3-0)3**
[MA 222 or Permission of Instructor]

A study of the basic structures of contemporary abstract algebra: groups, rings, modules, categories and functors. Fields and Galois theory.

MA 322 **Topics in Algebra** **(3-0)3**
[MA 321]

Current topics in modern algebra.

MA 334 **Projective Geometry** **(3-0)3**
[MA 222 or Permission of Instructor]

Foundations of Geometry. Homogeneous coordinates. Projective spaces. Conics. Linear transformations. Surfaces.

MA 359 or 360 **Digital Computer Programming** **(3-0)3**
[Permission of the Instructor]

An introduction to digital computer programming with concentration on the preparation of programs in the Fortran programming language. The Institute's IBM 1620 will be used for processing of practice problems.

MA 361 or 362 **Numerical Analysis** **(3-0)3**
[Permission of Instructor]

Selected mathematical and numerical methods of solving engineering problems, especially those suitable for the Institute's IBM 1620; computer solutions of algebraic, transcendental, and ordinary differential equations.

MA 381-382 Operations Research (3-0) (3-0)6
[Permission of Instructor]

The use of decision models in industrial systems. Quantitative approach to industrial alternatives. Fundamentals of probability and statistics, manufacturing and production models, time value of money, replacement analysis, statistical control, waiting line models, linear and dynamic programming, and theory of games.

MA 383 or 384 Statistical Methods (3-0)3
[MA 108]

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 395-396 Mathematics Seminar (1-0) (1-0)2

Reading, reports, and problem solving, pointing toward logical integration of the student's undergraduate work.

MA 405* or 406* Mathematical Statistics (3-0)3
[MA 205]

Measurements of dispersion, theoretical frequency distributions, tests of goodness of fit and independence, partial and multiple correlations; permutations, combinations, and probability; game theory.

MA 411* Complex Variables I (3-0)3
[MA 206]

Complex numbers, point sets, and elementary functions; an introduction to analytic functions; classification of singularities; line integrals; Cauchy integral formula; power series; and residues and poles.

MA 412* Complex Variables II (3-0)3
[MA 411]

Conformal mapping, Schwarz-Christoffel transformation, applications, and further topics in Theory of Functions.

MA 431* **Topology I** **(3-0)3**
[MA 307 or Permission of Instructor]

Topological Spaces. Continuity. Compactness and Connectedness. Product and Quotient Spaces. Metric Spaces. The fundamental group. Topological groups.

MA 432* **Topology II** **(3-0)3**
[MA 431]

Continuation of MA 431.

MA 433* or 434* **Matrix Algebra** **(3-0)3**
[MA 205]

Algebra of vectors, matrices, and determinants; linear transformations; linear vector spaces; characteristic roots and reduction to diagonal form; quadratic forms; and applications to physics.

MA 484* **Probabilities** **(3-0)3**
[MA 205]

Elements of combinatorial analysis, introduction to probabilities, random variables and expectation, law of large numbers, central limit theorem, and elements of mathematical statistics.

MA 495-596 **Mathematics Seminar** **(1-0) (1-0)2**

Reading, reports, and problem solving, pointing toward logical integration of the student's undergraduate work.

MA 505-506 **Mathematical Methods of Physics** **(3-0) (3-0)6**

Elements of complex variables; Fourier and other transforms; ordinary differential equations and their classification, and Frobenius and other methods of solution; partial differential equations and their classification; boundary value problems, Sturm-Liouville theory and eigenvalues; vector spaces; Green's functions and integral equations of the first and second kind; and introduction to group theory.

MA 533 **Matrix Theory** **(3-0)3**
[MA 205 or Permission of Instructor]

Algebra of vectors, matrices and determinants; linear transformations and vectors, matrices and determinants; linear

transformations and vector spaces; characteristic values and diagonal forms; calculus of matrices, matric polymomials, matric differential equations and applications.

MA 541 or 542 Fourier Series and Boundary Value Problems (3-0)3
[MA 206]

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics, and boundary value problems.

MA 575 or 576 Operational Mathematics (3-0)3
[MA 206]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentiation, and integration. Elementary applications in the analysis of vibrations, deflections, and electric circuits; problems in partial differential equations; and Fourier transforms.

MA 585 or 586 Random Processes and Noise Theory (3-0)3
[Permission of Instructor]

Principles of random noise theory and optimum filtering. Development of the concepts of correlation function and power spectra for the detection of signals in noise. Illustration of the theory in some applications of circuits and computers with emphasis on the formulation of the noise problem, its mathematical solution, and the interpretation of the results for proper design of systems.

MA 591 or 592 Graduate Thesis Credits to be arranged

The graduate thesis covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the Department Head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

MA 595-596 Mathematics Seminar Credit to be arranged

Introduction to mathematical research through reading, reporting, and critical evaluation of assigned topics.

MECHANICAL ENGINEERING

ME 104 **Design Graphics** **(1-2)1**

The design process; sketching; pictorial methods; conventional representation; graphs, diagrams; presentation of ideas.

ME 203 **Manufacturing Techniques and Communication** **(2-1)1**
[ME 104]

Communication, metrology and manufacturing processes in engineering. Precision of measurement; limits, fits and tolerances; layouts; details and assemblies; fasteners; engineering materials; manufacturing methods; machine tool operations; shaping, forming and casting.

ME 211 **Mechanics I** **(3-0)3**
[MA 108, PH 103]

Vector concepts of force and the moment of a force; the equilibrium requirements for rigid and deformable bodies. Force and deformation analysis including statically indeterminate situations. The concept of stress and strain at a point. The stress-strain-temperature relations.

ME 212 **Mechanics and Properties of Matter** **(4-0)4**
[MA 206 taken concurrently]
[Primarily for EE Students]

This course covers selected topics in Mechanics which are of fundamental importance to students majoring in Electrical Engineering. These include kinematics, Newton's laws, work, energy, free and forced harmonic oscillations, rotational motion of rigid bodies, stress and strain relationships, moduli of elasticity and wave motion. The treatment is at the intermediate level.

ME 215 **Analytic Mechanics I** **(3-0)3**
[MA 108, PH 103]
[Primarily for CN, PL, and TE Students]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 **Analytic Mechanics II** **(3-0)3**
[ME 215]
[Primarily for CN, PL, and TE Students]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 220 **Mechanics of Materials I** **(3-0)3**
[MA 205, ME 211]

Stress and deformation analysis of bodies under axial, torsional, flexural, and combined loading. Composite materials. Energy methods. Buckling.

ME 261 or 262 **Machine Tool Laboratory** **(1-2)1**
[Primarily for IM and PL Students]

The use of basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, gears, and gearing.

ME 275 or 276 **Materials Science** **(3-2)3**
[CH 002 and PH 203]

Materials for use in engineering applications are presented in general terms of their mechanical behavior, the thermodynamics of their structures, and their properties as related to their atomic and crystalline structure. The specific differences and similarities between metals, polymers and ceramics are emphasized.

ME 301 **Mechanical Engineering Laboratory I** **(0-3)1**
[ME 220, ME 276, ME 309 Concurrently]

Use of various testing equipment to establish material parameters used in solid mechanics analysis. Application to both new and traditional structual materials.

ME 309 **Dynamics I** **(3-0)3**
[MA 206, PH 104]

Kinematics of a particle with respect to fixed and moving coordinate systems of one, two, and three dimensions. The

dynamics of a particle, system of particles, and rigid bodies. Angular momentum and the inertial properties of rigid bodies. Euler's Equations. D'Alembert's principle. Impulse and momentum.

ME 314 Mechanical Engineering Laboratory II (0-3)1
[ME 342 and ME 382 Concurrently]

Tests on various energy conversion devices in order to illustrate principles of thermodynamics and fluid mechanics. The student is encouraged to design his own method of experimentation to arrive at the required results.

ME 315 Applied Mechanics (3-0)3
[MA 108, PH 103]
[Primarily for IM Students]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 320 Machine Design I (2-3)3
[ME 220, ME 309]

The principles of mechanics, and commonly used theories of failure are applied to the analysis and design of typical machine elements which are subjected to various loading conditions. Laboratory work requires the solution of comprehensive machine design problems that illustrate the close relationship between analysis and synthesis in design. Methods of writing clear and coherent design reports are emphasized.

ME 341 Thermodynamics I (3-0)3
[MA 205, PH 203]

A detailed development of the first and second Law as applied to an open and closed system in steady and unsteady flow. Thermodynamic properties of pure substances, condensible vapors and the perfect gas. The concept of entropy, reversibility, irreversibility, and availability.

ME 342 Thermodynamics II (3-0)3
[ME 341]

The application of the laws of thermodynamics to energy conversion cycles for vapors and perfect gases. Thermodynamic relations, mixtures and solutions, phase and chemical equilibrium, and the thermodynamics of compressible flow.

ME 344 **Heat and Power** **(3-0)3**
[MA 108, PH 104]
[Primarily for IM Students]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 345 **Thermodynamics** **(3-0)3**
[MA 205, PH 203]
[Primarily for TE Students]

The fundamentals of engineering thermodynamics arre covered. Properties of fluids, and mixtures of gases and vapors. Application to power and refrigeration cycles; humidity problems; combustion problems.

M E 347 **Elements of Thermodynamics and Heat Transfer** **(3-0)3**
[MA 205, PH 203]
[Primarily for EE Students]

A study of the first and second law of thermodynamics with application to systems and changes of state. Heat transfer by conduction, convection, and radiation. Steady and unsteady cases.

ME 351 **Measurement** **(3-0)3**
[EE 212, MA 206]

A study of the basic concepts and principles associated with the use and design of instruments for measuring various physical quantities. Mode of operation, accuracy. Statistical methods for evaluation of reliability of measurements. The role of measurements in control systems.

ME 372 **Strength of Materials** **(3-0)3**
[ME 315]
[Primarily for IM Students]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses.

ME 374 **Plastics Mold Design and Construction** **(1-2)1**
[ME 261 or ME 262]
[Primarily for PL Students]

A study of the basic types of plastic molding machines

along with the basic principles of mold design and construction. The design and construction of simple molds is carried out by actual laboratory work for use on the plastic machines in the Department of Plastic Technology.

ME 377 Elements of Materials Science (2-0)2
[Primarily for IM and TE Students]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, strain hardening and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 382 Fluid Mechanics I (3-0)3
[MA 301, MA 302 concurrently]

Rigorous mathematical development of basic fluid mechanical relations; continuity, momentum, and energy equations. Lagrangian vs. Eulerian approaches. Applications to inviscid and viscous, incompressible flows. Similarity and dimensional analysis. Boundary layer concepts and mathematical description. Fundamentals of turbulence. Introduction to low speed aerodynamics. Development of angular momentum principles and their application to turbomachinery.

ME 384 Fluid Mechanics (3-0)3
[MA 205, PH 203]
[Primarily for TE Students]

Fluid statics; pressure and fluid forces, buoyant forces. Flow of "ideal" fluids. Equations of continuity and momentum. Potential flow. Dimensional analysis; π -theorem. Flow of "real" fluids; viscous effects, boundary layer, drag, pipe networks, open channel flow. Fluid measurements, and turbomachinery.

ME 415 Mechanical Engineering Laboratory III (0-3)1
[ME 342, ME 382, ME 443 Concurrently]

Continuation of ME 314. Experiments designed to demonstrate principles of thermodynamics, fluid mechanics, and heat transfer.

ME 416 **Senior Project** **(0-3)1**
[Senior Standing]

Direct engineering experience in planning, executing, and reporting of an individual project selected by the student in consultation with the M.E. Staff Members.

ME 417 **Dynamics II** **(3-0)3**
[MA 302, ME 309]

Work-energy relation. Conservative force fields. Impulse and Momentum. Conservation of energy. Generalized coordinates and Lagrange's Equations. Vibrations of single and multiple degree of freedom systems.

ME 419 **Nondestructive Evaluation Techniques** **(3-0)3**
[Senior Standing]

The nondestructive evaluation of materials and processes by penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitations of each. Particular emphasis is placed upon the analysis and correlation of the interactions of these energy forms with material properties and processes. Flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical, and metallurgical properties.

ME 421 **Machine Design** **(2-3)3**
[ME 215, ME 216]
[Primarily for TE Students]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes, bearings, gears, and cams. Theories of failure and methods of establishing working stress levels are considered.

ME 422 **Machine Design II** **(2-3)3**
[ME 320]

A continuation of ME 320. Laboratory problems emphasize aspects of the overall design process; the use of the layout, (graphic), tool in machine design; the compromise between theoretical and practical considerations; optimum design criteria.

ME 430 **Design of Mechanical Systems** **(3-0)3**
[ME 320, ME 417, ME 497]

Solution by the student of problems involving the analysis and synthesis of mechanical engineering problems with primary emphasis on the area of applied mechanics and controls. A minimum of one major design project is completed under the supervision of M.E. staff members. Consideration of the design process including problem definition, solution synthesis, design analysis, trade off and optimization.

ME 441 **Statistical Thermodynamics** **(3-0)3**
[MA 302, ME 342]

Statistical mechanics for systems of independent particles. Quantum mechanics for particle motion. Thermodynamic properties of monatomic gases and solids, and polyatomic gases. Irreversible processes, Onsager relations.

ME 442 **Design of Thermal Systems** **(3-0)3**
[ME 443, ME 497]

Solution by the student of problems involving the analysis and synthesis of mechanical engineering problems with primary emphasis on the area of thermal-transport science and controls. A minimum of one major design project is completed under the supervision of M.E. Staff Members. Consideration of the design process including problem definition, solution synthesis, design analysis, trade off and optimization.

ME 443 **Heat Transfer** **(3-0)3**
[MA 302, ME 341, and ME 382]

Mathematical theory and applications of steady and transient heat conduction in solids. Heat transfer in convection and application to heat exchangers. Hydrodynamic and thermal boundary layer theory. Development of thermal radiation theory and its application to heat exchange with and without absorbing gases. Combined heat transfer by conduction, and radiation.

ME 445 **Heat Transfer** **(3-0)3**
[MA 206, ME 345, ME 384]
[Primarily for TE Students]

General heat transfer fundamentals and methods of analysis for problems involving conduction through solids during both steady state and transient conditions, heat exchange by

thermal radiation, free convection, forced convection, finned surfaces, tube bundles and heat exchangers.

ME 446 — Energy Conversion — (3-0)3
[EE 212, MA 302, ME 441 and ME 443]

Concepts of thermodynamics pertaining to energy conversion. Solid-state phenomena involved in conversion processes; energy forms, equations of state, and energy fields. Conversion methods using thermal cycles, thermoelectric devices, thermionic devices, magnetohydrodynamic generators, fuel cells, and photoelectric principles. Introduction to electromechanical energy converters. The concept of efficiency, and losses in these systems.

ME 452 — Applications of Numerical Analysis — (3-0)3
[MA 359, or 360; Senior Standing]

Iterative solutions of transcendental equations. Rapidity of convergence and estimate of error. Method of least squares. Extrapolation to the limit. Numerical differentiation. Numerical and Gaussian quadrature. Romberg integration. Numerical solution of first order, ordinary differential equations. Predictor and corrector formulas. Finite difference solutions of second order, partial differential equations. Applications to problems in fluid mechanics, solid mechanics, and heat transfer. Solutions set up and carried out on digital computer.

ME 468 — Fluid Machinery — (3-0)3
[ME 382]

Review of thermodynamic principles, incompressible and compressible fluid mechanics. Classical turbine theory, (one-diminsional treatment). Cascade mechanics. Thin air-foil theory. Flow in three dimensions. Loss mechanism; boundary layers; cavitation.

ME 472 — Experimental Stress Analysis — (2-3)3
[ME 220]

An introduction to the Theory of Elasticity; the determination of stress and strain distributions by experimental methods. Photoelasticity, birefringent coatings, brittle coating, analogies, strain gage applications, rosette analysis.

ME 473 **Mechanics of Materials II** **(3-0)3**
[MA 302, ME 220]

The state of stress at a point; theories of failure by yielding; energy methods; inelastic buckling; buckling of tubes; shear center; unsymmetrical bending; curved flexural members; torsional resistance in non-circular sections.

ME 475 **Physical Metallurgy** **(3-0)3**
[ME 276]

A detailed study of the theories discussed in materials science as they apply more specifically to metals. These include dislocation and slip phenomena, recrystallization and grain growth, diffusion, precipitation hardening, solidification of metals, martensite reactions, X-Ray diffraction and fracture.

ME 482 **Fluid Mechanics II** **(3-0)3**
[MA 302, ME 382]

Extension of basic equations of motion and energy to inviscid, compressible fluids. Acoustic equations. One-dimensional, steady flows with area change. Fanno and Rayleigh flows. Normal and oblique shocks. Crocco's theorem. Prandtl-Meyer expansion. General linerarized theory with applications. Method of characteristics. Introduction to real gas effects.

ME 488 **Environmental Conditioning** **(3-0)3**
[ME 443]

The control of thermal environment within enclosed spaces including transfer of heat and work energy. Refrigeration cycles, heating, humidification, dehumidification and mixtures. Design of conditioned spaces.

ME 493 or 494 **Industrial Instrumentation** **(2-0)2**
[MA 108, PH 104]
[Primarily for PL Students]

Modern Methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric, and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; close-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

ME 495 **Electromechanical Engineering** **(3-0)3**
[EE 212, MA 206]
[Primarily for TE Students]

Characteristics of electromechanical transducers and their associated circuitry as employed in the measurement of acceleration, velocity, displacement, stress, strain, thickness, mass, weight, frequency, time, and level of intensity.

ME 497 **Automatic Control Systems I** **(3-0)3**
[EE 212, MA 302, ME 351]

Concept of open and feedback control systems. Use of block diagram and transfer functions for system representation. Analytical techniques for evaluation of system performance, transient and steady state response, stability and compensation. Consideration of hydraulic, pneumatic and electromechanical control systems.

ME 498 **Automatic Control Systems II** **(3-0)3**
[ME 497]

The design, analysis and application of hydraulic, pneumatic and electromechanical control systems; regulators and servomechanisms; multiple loop systems. System improvement; treatment of nonlinear systems.

ME 528 **Kinematic Mechanism Synthesis** **(3-0)3**
[ME 309]

Mechanism concepts, symbolic notations, coupler curves, and the Gruebler criterion. Planar linkage synthesis by geometric methods, synthesis of function generators and dwell linkages, and the Euler- Savory equation. Analytic methods of synthesis, Freudenstein's method, kinematics of spatial mechanisms, matrix representation of rotation, and general matrix methods of analysis.

ME 562 **Engineering Analysis** **(3-0)3**
[Senior Standing]

A study of the methods used in engineering analysis with emphasis on the basic types of underlying mathematics. Problem examples include both discrete and continuous systems encountered in the fields of solid mechanics, fluid mechanics, heat transfer, and electrical networks.

METEOROLOGY

MY 201 or 202 General Meteorology (3-0)3
[MA 108; PH 104]

Atmospheric heat balance. Average distribution of temperature, water vapor, and air motion. Introduction to atmospheric thermodynamics and hydrodynamics. Anticyclones and air masses. Cyclones and fronts. Formation and distribution of fog, clouds, thunderstorms, and tornadoes. Elements of tropical meteorology.

MY 303-304 Atmospheric Physics (3-0) (3-0)6
[MY 201 or 202; MA 205 Concurrently]

Thermodynamics of dry air, water vapor and moist air. Hydrostatic equilibrium of the atmosphere and its stability. The equations of motion for the atmosphere. Thermal circulation. Motion under balanced forces. Eddy viscosity. Introduction to numerical weather prediction and general circulation theory.

MY 305 Synoptic Meteorology (1-6)3
[MY 201 or 202]

Introduction to meteorological instruments and observations and to weather analysis and forecasting.

MY 306 Physical Climatology (3-0)3
[MY 201 or 202]

Analysis of the physical processes producing the observed geographic distribution of climates and their variations with time. Fluctuations of the radiation balance. The hydrological cycle. Introduction to microclimatology.

MY 401-402 Weather Analysis and Forecasting (0-9) (0-9)6
[MY 305]

Applications of the principles of atmospheric thermodynamics and hydrodynamics to the analysis and forecasting of weather conditions in the troposphere and lower stratosphere. Studies in the structure, development, and motion of weather systems. Practice in the techniques of short and long range weather forecasting.

MY 403 **Physical Meteorology** **(3-0)3**
[MY 304]

Solar and terrestrial radiation processes. Propagation of sound in the atmosphere. Propagation of light and other electromagnetic waves in the atmosphere. Evaporation and condensation processes. Atmospheric chemistry and air pollution. Physics of the high atmosphere.

MY 405-406 **Individual Studies** **(1-0) (1-0)2**
[MY 304]

Research or literature survey on specific meteorological or climatological problems and submission of a written paper to the department.

MY 407-408 **Hydrometeorology** **(2-0) (2-0)4**
[MY 306]

Study of the meteorological aspects of oceanography, limnology and hydrology; the interaction between the atmosphere and oceans, lakes, streams, ground water, and vegetation.

MY 410 **Statistical Methods in Meteorology** **(3-3)4**
[MY 304]

Frequency distributions and their properties. Sampling techniques and problems. Relationships between variables. Analysis of time series and of spatial variation. Statistical forecasting and forecast verification. Experimental design and factor analysis.

NUCLEAR ENGINEERING

NU 201-202 **Introduction to Nuclear Engineering** **(3-0) (3-0)6**

A general review of atomic and nuclear structure, the properties of nuclear radiations, and radiation measurement. Nuclear forces and nuclear structure. Neutrons and fission. Utilization of nuclear energy. Nuclear reactors. Fuels and fuel reprocessing. Health Physics and radiation protection. Accelerators. Fusion reactions and the long-term energy picture.

NU 302 **Radiological Health** **(3-0)3**

Nature, sources and effects of radiation. Mechanisms. Absorption and attenuation. Effect on living matter. Somatic

and genetic effects. Maximum permissible doeses and concentrations. Dosimetry. Shielding. Ventilation. Contamination. Waste disposal. Regulations and compliance.

NU 305-306 Nuclear Instrumentation (2-4) (2-4)8

The first semester lectures cover the fundamentals of circuit theory as applied to pulse circuits, and the laboratory covers the construction, testing, and evaluation of component circuits and instruments. The second semester lectures are devoted to the design and operating characteristics of detectors and their use with electrometers, ratemeters, scalers, and pulse height analyzers. The laboratory work of the second semester is devoted mainly to the characteristics of detectors and associated measuring circuits.

NU 405-406 Nuclear Reactor Engineering (3-0) (3-0)6

Neutrons, cross-sections and fission. Steady state and the criticality condition. Reflected, homogeneous and heterogeneous reactors. Fast reactors. Reactor control. Kinetics and reactivity effects. Control systems and instruments. Coolants and moderators. Fuels. Reactor Operations.

NU 493-494 Advanced Nuclear Laboratory (0-6) (0-6)6

Neutron activation experiments. Szilard Chalmer experiment. Measurements of slowing down lengths, diffusion lengths. Fermi Age. Effect of poisons in moderators as well as insertion of control rods. Experiments on reactor simulator including period measurements and effects of poison. Experiments on accelerator and reactor.

PAPER ENGINEERING

PA 301 Engineering Analysis of Pulp Systems (3-0)3
[CN 204]

Lectures and problems concernined with the engineering, design and technology of pulp manufacturing by all commercial processes. Discussion of bleaching chemistry and use of secondary fibers.

PA 302 Engineering Analysis of Paper Systems (3-0)3
[PA 301]

Discussion and study of engineering, design and econom-

ics of commercial methods of production of papers. Stock preparation; changes in physical and chemical properties of pulps; filling and loading of fibers; sizing, coloring and other additives. Material and energy relationships of various processes.

PA 307 Physical Testing and Analysis of Data (3-0)3

Fundamentals of the mechanical and optical testing of paper and other materials. Discussion of engineering mechanics involved in various testing procedures. Statistical analysis of testing. Structure of material revealed by physical tests.

PA 308 Pulp and Paper Laboratory (0-6)2
[PA 301, taken concurrently with PA 302]

Laboratory projects designed to illustrate problems involved in the processing of pulp and paper. Evaluation of TAPPI test methods. Chemical and physical analysis of pulps and papers.

PA 403 Engineering Analysis of Converting Processes (3-0)3
[PA 302, PA 308]

Lectures and problems concerned with the engineering, design, technology and economics of paper and paperboard converting processes. Rheology of coating materials and engineering properties of materials. Mechanical, coating, impregnating, laminating and printing processes.

PA 405 Converting Laboratory (0-6)2
[PA 403 taken concurrently]

Common techniques employed in converting paper and paperboard and use of TAPPI Methods in evaluation. Emphasis is placed on the colloidal and rheological properties of materials used in coating. Detailed written and oral reports and required.

PA 410 General Analysis of Paper Processing (3-0)3
[PA 403]

Specific discussion of problems involving engineering design of paper and paper products. Emphasis on structure of basic cellulosic fibers and changes which can be made in properties. Colloidal chemical aspects of paper and pulp processing. Plant vistits in specialized subjects. Written and oral reports.

PA 501-502 Graduate Thesis Credits to be arranged

Every graduate student is required to write a thesis on original research work done under the supervision of a senior committee appointed by the Department Head.

PA 503-504 Advanced Converting Processes (3-0) (3-0)6
[PA 403, PA 405]

Specific converting processes. Analysis of coating processes: water- and solvent-based, extrusion and hot melts. Latest techniques used by the converting industry, involving mechanical and chemical operations. Engineering analysis of processes. Oral and written reports and plant visits.

PA 505 The Physics of Paper (3-0)3
[Approval of Instructor]

Structures of fibers from a fundamental viewpoint and their effect on strength and other properties of sheets made from these fibers. Comparison of cellulosic fibers and synthetic fibers. Engineering properties of fibrous materials.

PA 506 New Techniques in the Paper Industry (3-0)
[Approval of Instructor]

Lectures and discussion of new developments in engineering, design and application of physical and chemical principles in the manufacture of paper and paper products. Economic comparisons of new processes. Plant visits. Oral and written reports.

PA 508 Advanced Paper Systems Analysis (2-0)2
[PA 410]

Chemistry and engineering principles applied to nonfibrous components in papermaking. Discussion of alum chemistry, fillers and other additives.

PA 509 or 510 Economics of the Paper Industry (2-0)2
[Approval of Instructor]

An evaluation of the paper industry from an economic viewpoint. Examination of costs and availability of different raw materials, additives and finishing materials. Analysis of competitive position of the paper industry and its products. Evaluation of foreign competition.

PA 512 Advanced Fiber Processing (3-0)3
[PA 302]

A study of fiber properties as related to fiber processing. Treatment of various theories of fiber processing. Discussion of mechanical treatments of fibers on the wet and dry properties of papers made from these fibers.

PA 530-531 Paper Engineering Seminar (1-0) (1-0)2

Required of all paper engineering graduate students.

PA 534 or 535 Special Paper Projects Credits to be arranged

[Approval of Instructor]

Special Projects laboratory undertaken by a student to expand his knowledge in specific fields not necessarily related to his thesis. Content of project and hours assigned must be approved by Department Head.

PHYSICS

PH 103 Physics (4-1)4
[MA 107 taken concurrently]

Mechanics: kinematics; dynamics - inertia, mass, momentum, force, impulse, application of Newton's laws, inertial and noninertial frames of reference, work, energy, rotational kinematics and dynamics, angular momentum, gravitation, elasticity, and the dynamics of simple harmonic motion.

PH 104 Physics (4-2)4
[PH 103 or equivalent]

Heat and kinetic theory. Thermodynamics, Carnot cycle, entropy. Elements of electricity: electrostatics, fields, flux, Gauss' law, electric potential; dc circuits, magnetism.

PH 203 Physics (4-2)4
[MA 205 taken concurrently; PH 104]

Electromagnetic induction, electric oscillations. Waves on strings, mechanical waves, electromagnetic waves, physical optics, and basic geometrical optics. Introduction to modern physics.

PH 205 **Physics III** **(4-2)4**
[MA 205 taken concurrently; PH 104]

Electromagnetic induction and oscillatory phenomena. Mechanical oscillators; traveling elastic waves; standing waves; acoustical and optical wave phenomena, such as beats, the Doppler effect, reflection, refraction, interference, and diffraction; polarization; and spectra.

PH 206 **Physics IV** **(4-2)4**
[PH 205]

Review of classical ideas; the restricted theory of relativity; particle aspects of electromagnetic radiation; wave aspects of material particles; the hydrogen atom; many-electron atoms; x-ray spectra; nuclear accelerators; nuclear structure and nuclear reactions; and molecular and solid-state physics.

PH 209 **Problems in Physics** **(1-0)1**
[PH 205 taken concurrently]

Practice in the careful analysis of physical situations and in their formulation, by way of the solution of the specific problem posed. Problems of a level comparable with that of the accompanying elementary course are solved, and may be in any portion of the field previously or concurrently studied.

PH 210 **Practical Astronomy** **(3-0)3**
[MA 205]

Coordinate systems, marine navigation, space navigation, the gravitational potential, Keplerian orbits, and the rendezvous problem in space. The material is developed mainly through the solution of problems.

PH 244 **Optical Instruments** **(1-2)2**
[PH 205 taken concurrently]

The basic laws of optics and their application to various optical instruments used in industry, such as the microscope, telescope, refractometer, and colorimeter. Considerable emphasis in the laboratory work is placed on the general use of the microscope.

PH 257 **Electric Circuits** **(3-0)3**
[MA 205 taken concurrently; PH 104]

A short course designed to cover the fundamentals of cir-

cuit theory. Basic direct-current circuit theorems; simple transient problems in a.c. circuits; steady-state solutions for the simple series circuit: impedance and resonance; the parallel resonant circuit: admittance. Some mechanical analogs are derived. The elementary theory of differential equations and the complex variable are developed where needed. Outside work emphasizes the application of the theory to the solution of problems.

PH 293 Laboratory Practice (1-3)2
[Permission of Instructor]

Practice in laboratory techniques, such as glass blowing, simple machine work, and dealing with vacuum systems. The proper keeping of notebooks, the analysis and evaluation of data, and the writing of reports.

PH 294 Laboratory Practice (0-6)2
[MA 205, PH 205]

Precision of measurements, zero-frequency and low-frequency measurements by both deflection and null methods, amplifiers and tube electrometers, oscilloscopes, Geiger and proportional counters, magnetic measurements, and electrical measurements in mechanics, heat, acoustics, optics, and nuclear science.

PH 311-312 Intermediate Mechanics (3-0) (3-0)6
[MA 206; MA 301-302 taken concurrently]

Kinematics of a single particle, an analysis of Newton's laws of motion, the mechanics of a single particle in one and in more than one dimension, conservative and non-conservative forces, central forces, the mechanics of systems of particles from the points of view of Newton, Lagrange, and Hamilton, generalized coordinates and moments, the Hamiltonian function, rotating rigid bodies, moments and products of inertia, principal axes, the theory of small oscillations, normal modes of vibration, and the vibrating string.

PH 343-344 Atomic and Nuclear Physics (3-0) (3-0)6
[MA 206, PH 206; PH 311-312 taken concurrently]

Atoms as components of matter; particle beams in electric and magnetic fields; and magnetic, optical, and electrical properties of atoms. X-rays, photons and X-ray spectra, optical spectra, the special theory of relativity, the Schrodinger equa-

tion, and electron spin and multiplet spectra. Radioactivity, Rutherford scattering, nuclear radii, wave mechanics, cross sections, and nuclear reactions.

PH 345-346 Atomic and Nuclear Physics (3-0) (3-0)6
[MA 206, PH 206; PH 311-312 taken concurrently]

The special theory of relativity; relativistic mechanics; scalar invariants, 4-vectors, and tensors; the Lorentz transformation and particle collisions; an introduction to quantum mechanics; and the one-electron atom. The Pauli exclusion principle; atomic shell structure, the multielectron atom, and atomic spectroscopy; the Zeeman effect, the Stark effect, and the Paschen-Back effect; basic properties of nuclei; charge, mass, and magnetic moments; radioactivity; and excited nuclear state and nuclear reactions.

PH 347 or 348 Physical Optics (3-0)3
[PH 353 or 354]

The theoretical and experimental aspects of the phenomena of interference, diffraction, and polarization of electromagnetic waves, especially light and microwaves.

PH 353-354 Electromagnetic Theory (3-0) (3-0)6
[MA 301-302 taken concurrently; PH 205]

The theory of electromagnetic fields using vector analysis and Maxwell's equations. Static electric and magnetic fields in dielectrics, conductors, and ferromagnetic materials; the scalar and vector potentials and time-varying fields; and the special theory of relativity. Plane waves in dielectrics and conductors, the Poynting vector, Fresnel's equations, and waveguides; radiation from antennas and accelerated charges;ipolarization, interference, and diffraction; and receivers.

PH 363 Introductory Nuclear Physics (3-0)3
[For students majoring in Nuclear Engineering and in the Option in Nuclear Physics]

Natural radioactivity; the Bateman equations; isotopic abundance; induced activity; the nergetics of nuclear reactions; and alpha, beta, and gamma emission.

PH 366 Intermediate Nuclear Physics (3-0)3
[For students majoring in Nuclear Engineering and in the Option in Nuclear Physics]

The compound nucleus and resonance theory, cross sec-

tions, Rutherford scattering, center of mass coordinates, neutton physics, nuclear radii, nuclear stability and forces between nucleons, and nuclear models.

PH 393-394 Experimental Physics (0-6) (0-6)4
[Permission of Instructor]

Experiments in electromagnetics, optics, electronics, atomic and nuclear physics, mechanics, and other interesting fields.

PH 405 Introduction to Theoretical Physics (3-0)3
[PH 312, PH 354]

A study of mechanics, field theory, variational methods, and other aspects of theoretical physics.

PH 411-412* Quantum Theory (3-0) (3-0)6
[MA 433 and MA 484 taken concurrently; PH 311 or 312]

The beginnings of the quantum theory. The Bohr-Sommerfeld theory; wave-particle dualities and the uncertainty principle; the DeBroglie theory; basic principles of wave mechanics; Schrodinger's equation and application; operators and observables; commuting properties of operators and their relationships to the uncertainty principle; mathematical theory of eigenfunctions, Fourier series, and the Fourier integral; matrix mechanics; perturbation theory by wave and matrix mechanics; and applications.

PH 423* Thermodynamics (3-0)3
[MA 205]

A macroscopic analysis of the behavior of thermodynamic systems including the following topics: thermodynamic equilibrium states, the concept of temperature, the first law of thermodynamics, real and ideal gases, the ideal gas temperature scale, heat engines and refrigerators, the second law of thermodynamics, reversible processes, the Carnot cycle, the Kelvin temperature scale, the concept of entropy and its philosophical significance, pure substances, enthalpy, Helmholtz free energy, Gibbs free energy, Maxwell's relations, the TdS equations, and applications found in modern physics.

PH 424* Introduction to Statistical Mechanics (3-0)3
[PH 312, PH 411, PH 423, MA 484]

A continuation of PH 423, but at a microscopic level and including the following topics: probability theory, the classical

statistical mechanics of Gibbs, phase space, phase density, Liouville's theorem, the microcanonical, canonical, and grand canonical ensembles, the partition function, the statistical mechanical interpretation of the thermodynamic functions and laws, modifications required by quantum mechanics, the Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distribution laws, and applications of the theory to ideal gases.

PH 431 or 432* Theory of Vibrations and Sound (3-0)3

[MA 301, PH 312]

Free, damped, and forced oscillations; forcing by pulses; coupled oscillations; the flexible string; end conditions; perturbations; the vibration of bars, membranes, and plates; sound waves; acoustic impedance; the radiation and scattering of sound; normal modes; and reverberation. Applications are stressed.

PH 436 Theory of Waves (3-0)3

The wave equation, solutions of the wave equation, the superposition principle and Fourier analysis, energy transport in waves, dispersion and diffraction of waves, geometrical wave theory, applications to electromagnetic theory, optics, and wave mechanics.

PH 441-442 Introduction to Relativity and Quantum Mechanics (3-0) (3-0)6

[MA 301-302, PH 345-346]

The special theory of relativity; relativistic mechanics; scalar invariants, 4-vectors, and tensors; the Lorentz transformation and particle collisions; an introduction to quantum mechanics; and the one-electron atom. The Pauli exclusion principle; atomic shell structure, the multielectron atom, and atomic spectroscopy.

PH 443 Spectrographic Methods (2-3)3

[PH 206]

A course exploring the merits of spectroscopy as a tool for the investigating scientist. The theoretical prediction of line and band spectra and the theory and operation of various spectrograph designs.

PH 445 X-Ray Diffraction (2-3)3

Theory of X-ray production; absorption; scattering by elec-

trons and atoms; crystallographic notation; Laue equations; and determination of crystal structure. For those whose background interests involve fibers, some opportunity for investigation of these is offered in the laboratory work.

PH 448 — Electron Microscopy and Electron Diffraction — (2-3)3
[PH 206]

Analogies with optics, electrostatic and magnetic lenses, electron trajectories, the scattering of electrons, electrons, electron diffraction and the wave properties of the electron, vacuum techniques, thin films by vacuum evaporation and electropolishing, specimen preparation, qualitative and quantitative evaluation of the electron image, and photographic techniques.

PH 449 or 450 — Infrared Radiation — (2-3)3
[PH 206]

The use of infrared radiation as a means of scientific investigation. The laws and theories of black body radiation, including those of Planck, Wien, and Stefan-Boltzmann. The theory and operation of various infrared detectors and systems of collecting optics.

PH 454 — Piezoelectric Crystals — (2-3)3
[PH 311, PH 353]

Phenomena in piezoelectric crystals and measurements of related quantities. Parameters of the equivalent circuit of a resonator, vibrational modes, elestic coefficients and temperature effects, the consequences of cutting plates of different orientations, and effects of surface shaping. Applications such as in transducers, frequency stabilization, ultrasonic wave generation, wave filtering, and clock control.

PH 462* — Nuclear Physics — (3-0)3
[MA 302; PH 344 or 366]

Ionization of matter by charged particles, mass-energy relationships, packing fraction, elementary discussion of properties of a nucleus, radioactive decay, systematics of alpha and beta decay, alpha decay theory, gamma emission, two nucleon systems, nuclear reactions and nuclear structure, and properties of neutrons.

PH 471-472* **Solid-State Physics** **(3-0) (3-0)6**
[PH 411-412 taken concurrently]

Crystal structure and X-ray and neutron diffraction; free electron model; band theory of solids; quantum mechanical considerations; lattice energy, lattice vibrations, and infrared absorption; lattice defects; thermal properties of solids; dielectric and magnetic properties; mechanical properties; and semiconductor crystals.

PH 493-494 **Advanced Laboratory** **(1-3) (1-3)4**
[Permission of Instructor]

A laboratory course which accompanies the senior courses in the department, and which may serve as a vehicle for undergraduate experimental research in selected fields of physics and for practice in exposition or in teaching.

PH 495 or 496* **Special Research Problems** **Credits to be arranged**
[Permission of Head of Department and Instructor]

Special problems in theoretical and experimental physics assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

PH 497-498* **Biophysics Seminar** **(1½-0) (1½-0)2**

A seminar type course with the students leading discussions on almost any topic of physical interest in biology, but with emphasis on the following: the living cell, its structure and functions, how it moves, divides, and transforms energy, enzymes, the structure of proteins and nucleic acids, the DNA and RNA molecules, the gene and the genetic code, the mechanism of muscle contraction, the electrical nature of cells, the nerve impulse, biological transducers, the ear, the eye, brain waves, psychophysics, artificial "life", and the origin and evolution of living systems.

PH 507 **High-Energy Physics** **(3-0)3**
[PH 516]

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation laws of high-energy physics, strong and weak interactions, and an introduction to the theory of unitary symmetry and its consequences.

PH 511-512 Classical Mechanics (3-0) (3-0)6
[PH 312]

An analysis of the mechanics of systems of particles from the points of view principally of Newton, Lagrange, and Hamilton, including the following topics: Newton's laws, conservative and non-conservative forces, holonomic and non-holonomic constraints, Lagrange's equations, Hamilton's principle, orthogonal transformations, the motion of rigid bodies, rotating frames of reference, the rotation of a symmetrical rigid body, Hamilton's equations, the principle of least action, canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action and angle variables, and a comparison between classical mechanics and geometrical optics.

PH 515-516 Quantum Mechanics (3-0) (3-0)6
[MA 433, PH 411; PH 511-512 taken concurrently]

Wave packets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum, spin, and time-dependent and independent perturbation theory. Scattering theory.

PH 517-518 Advanced Quantum Mechanics (3-0) (3-0)6
[PH 516]

The formal theory of scattering. The Klein-Gordon and Dirac equations, the Foldy-Wouthuysen transformation, elements of covariant perturbation theory based on Feynman's propagator approach, and renormalization theory. Secon quantization and canonical commutation rules, the connection between spin and statistics, the TCP theorem, and selected topics in strong and weak interactions.

PH 519 or 520 Theory of Weak Interactions (3-0)3

The four-Fermi interaction, beta decay, two-neutrino theory, violation of space and time symmetries, conservation laws and selection rules, conserved vector current, SU (3) transformation properties of the weak Lagrangian, and electron and muon neutrinos and the intermediate vector boson.

PH 521 or 522 Statistical Mechanics (3-0)3
[PH 424]

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and

Bose-Einstein, and applications to thermodynamics, solid-state physics, and nuclear physics.

PH 523 or 524 Low-Temperature Physics (3-0)3
[MA 302; PH 423]

The production of low temperatures; temperature measurement; liquid helium; superfluids and superconductors; paramagnetic salts; the magnetic temperature scale;inuclear polarization and alignment; termal conductivity at low temperatures; the third law of thermodynamics; and adiabatic demagnetization.

PH 531 or 532 Acoustics (3-3)4

Not offered in 1968-69.

PH 537 Group Theory (3-0)3

Group theory and its application to the quantum theory, symmetry properties and conservation laws, crystalline fields, Lie groups, an analysis of the rotation and Lorentz groups, a general analysis of SU (n), and applications.

PH 552 Astrophysics (3-0)3
[PH 206, PH 311]

The origin and future of the universe, using mathematical treatment wherever practicable. Theorems needed beyond the prerequisites are developed in the course.

PH 553 or 554 Piezoelectricity and Ferroelectricity (3-3)4

Crystallographic bases of piezoelectricity, crystal elasticity, rotated axes, modes of vibration; behavior and interactions of the elastic, dielectric, and piezoelectric coefficients; ferroelectric crystals, domain structure, transitions between phases, free and clamped states; and applications of piezoelectric and ferroelectric crystals.

PH 555 or556 Plasma Physics (3-0)3
[PH 354]

The production of high-intensity electromagnetic and electrostatic fields and the interaction of these with conducting forms of matter. The physics of high-temperature, low-density gases, with emphasis on practical applications.

PH 557-558 Electricity and Magnetism (3-0) (3-0)6
[MA 301-302, PH 353-354]

Electrostatics and magnetostatics with special attention to boundary-value problems. Quasistatic fields and displacement currents, Maxwell's equations, the Special Theory of Relativity, Lienard-Weichert potentials, and radiation from an accelerated charge. Waveguides, scattering, and applications to the problems of modern-day physics.

PH 561 or 562 Nuclear Physics (3-0)3
[PH 462]

Stationary states of nuclei, nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles, gamma rays, and neutrons; nuclear forces and nuclear models; and fast neutron physics.

PH 565 or 566 Nuclear and Electron Spin Resonance Phenomena (3-0)3
[PH 411-412 taken concurrently]

An introduction to crystal field theory and electron spin resonance; coupling of angular momenta; nuclear electric quadrupole and magnetic resonance; application to gases, liquids, and crystals; and a survey of experimental techniques.

PH 567 or 568 Neutron Diffraction Analysis (3-0)3

The diffraction of neutrons in crystals and its applications in the determination of lattice structures and magnetic moments.

PH 569-570 Nuclei, Particles, and Accelerators (3-0) (3-0)6
[MA 301-302 or equivalent; PH 343-344 or equivalent]

The passage of radiation through matter, detection methods for nuclear radiations; accelerators; radioactive decay, elements of nuclear structure and systematics, alpha emission, gamma emission, beta decay, the two-body system, nuclear reactions, and neutrons.

PH 571-572 Lattice Imperfections (3-0) (3-0)6

A description of point, line, and plane imperfections in crystals, and their properties, causes, and interactions; the

influence of imperfections on electron and phonon transport phenomena and also on lasers; a study of imperfections by X-ray and electron diffraction; and a discussion of problems in current literature.

PH 573-574 Quantum Theory of Solids (3-0) (3-0)6

Acoustic and optical phonons; plasmons; the Hartree-Fock approximation; many-body theory;ielectron-phonon interactions; the band theory of solids; metals; semiconductors; transport theory; neutron diffraction; superconductivity; magnetism; and magnetic resonances.

PH 575-576 Problems in Solid-State Physics (3-0) (3-3)7

Quantum mechanics and specific heats, lattice nergy, elastic coefficients, applications of statistical mechanics, ferroelectric crystals, diamagnetism and paramagnetism, Brillouin zones, Hume-Rothery rules, order-disorder transformations, semiconductors, ferromagnetism and antiferromagnetism, ferrimagnetism, magnet relaxation and resonance, superconductivity, lattice vacancies, diffusion, color centers, excitons, dislocations, and thermal and electrical conductivity at low temperatures.

PH 577-578 Thermodynamics of Solids (3-0) (3-0)6

The thermodynamics of first- and second-order phase changes; lattice energy and vibration spectrum; the Einstein-Debye model; nonideal solid solutions; order-disorder phenomena; crystal interfaces and imperfections; and applications to metals and semiconductors.

PH 583-584 General Theory of Relativity (3-0) (3-0)6

The invariance of physical laws; tensor formulation of the special theory of relativity and applications; and the general theory of relativity.

PH 591-592 Master's Thesis Credits to be arranged

The thesis for the master's degree covers an independent investigation undertaken by the student of a problem which is of interest to a member of the faculty and has the prior approval of the department head. The thesis must show ability and originality and must be a clear and systematic written presentation of the results.

PH 593-594 Graduate Laboratory **Credits to be arranged**

[Permission of Instructor]

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics.

PH 595-596 Physics Seminar **Credits to be arranged**

A discussion of timely topics by visiting scientists, staff, and graduate students. Required of all graduate students.

PH 601-602 Special Problems in High-Energy Physics **Credits to be arranged**

PH 603-604 Special Problems in Solid-State Physics **Credits to be arranged**

PH 605-606 Special Problems in Nuclear Physics **Credits to be arranged**

PH 651-652 Seminar in High-Energy Physics **Credits to be arranged**

PH 653-654 Seminar in Solid-State Physics **Credits to be arranged**

PH 655-656 Seminar in Nuclear Physics **Credits to be arranged**

PH 701-702 Research in High-Energy Physics **Credits to be arranged**

PH 703-704 Research in Solid-State Physics **Credits to be arranged**

PH 705-706 Research in Nuclear Physics **Credits to be arranged**

PLASTICS TECHNOLOGY

PL 201-202 Introduction to Polymeric Materials **(2-0) (2-0)4**

A descriptive subject to acquaint the student with plastics

as a class of materials. The history, definitions, classes, properties, and applications of plastics.

PL 301-302 Plastics Technology (2-2) (2-2)6
[PL 201 or Permission of Instructor]

Raw materials and manufacturing processes. Methods of processing plastics materials, including compounding, molding, casting, extruding, laminating, fabricating, and finishing. Evaluation and development of typical plastics problems. Laboratory instruction in the processing and fabrication of plastics materials.

PL 401-402 Plastics Technology (2-2) (2-2)6
[PL 301-302]

Application of plastics as engineering materials. Product, equipment, and mold design. Correlation of composition, processing, and fabrication with product design and applications. Continuation of laboratory instruction in processing, molding, and fabrication.

PL 403-404 Properties of Polymers (2-2) (2-2)6
[Open to seniors only]

Correlation of composition and structure with important engineering properties of plastics; environmental conditioning and effects of types of loading in evaluation of plastics materials; the theory of testing; critical examination of testing techniques, equipment, and standard ASTM methods of evaluating mechanical, thermal, electrical, and optical properties.

PL 411-412 Plastics Seminar (1-0) (1-0)2
[Open to seniors only]

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics technology.

SOCIAL SCIENCES

SS 223 The United States: 1865-1912 (3-0)3

With the unit approach, a study of the following: Political development from Reconstruction to the New Freedom, the rise of labor and industry after 1870, the rise of the West and its influence, diplomacy before World War I, and the social and cultural development of the American people.

Collateral readings will be required for each topic.

SS 224 The United States: 1912 to the Present (3-0)3
[No prerequisite, but SS 223 is recommended as background]

Continuing the topical analysis of SS 223, a study will be made of the political philosophies from Wilson to Johnson, the industrial problems of the 20th Century, the transition from isolation to free world leadership, economic cycles, the impact of science, and current issues.

Collateral readings will be required for each topic.

SS 225 Europe: 1789-1914 (3-0)3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the Frech Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 227 Europe: 1914-1939 (3-0)3

A study of the quarter-century in which the "Great War" and the postwar settlements and realignments created a new Europe and set the stage for World War II. Emphasis is given to the rise of totalitarianism and the changing power patterns in Continental Europe and the world at large.

SS 228 Europe: 1939 to the Present (3-0)3

A survey of the major events of World War II and the key factors in the postwar alignments. Particular attention is given to the roles of Soviet Russia and the United States, the effects of regionalism and internationalism, the decline of imperialism, and the economic, political, and social developments in the major nations in the period.

SS 301 Government of the United States (3-0)3

A study of the structure of the national government with attention to the modern developments in the powers and the functions of the three branches. Special emphasis is given to the making and implementation of both domestic and foreign policies.

SS 302 Conduct and Control of Foreign Policy (3-0)3

Consideration of the ways in which a state's conduct of its

foreign policy affects and is affected by both the substance and the processes of its domestic politics. Primary consideration is given to the United States and the principla nations of Western Europe.

SS 303 or 304 Psychology (3-0)3

An introduction to the basic principles of human behavior. Major areas covered include: Stages of human development, heredity, the senses, the connecting and reacting mechanisms, motivation and emotion, neuroses and psychoses.

SS 305 or 306 Sociology (3-0)3

The principles of Sociology, including the development of Man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 371 or 372 American Civilization to 1865 (3-0)3

A study of the development of national consciousness in America through a review and evaluation of economic, political, and social institutions and their influences upon U. S. culture.

SS 403 Psychological Warfare (3-0)3

Inquiry into the role of psychological warfare in modern foreign policy. Special attention is given to such activities as economic aid, technical assistance, military missions, cultural exchanges, and information services of various types.

SS 459 World Politics: The Central Problem of War (3-0)3

War as the central phenomenon of world politics — Its causes and functions in theory and in history; its effects on the individual and society; efforts to control it; and the ethical problems that it raises.

SS 460 Foreign Aid and Foreign Policy (3-0)3

A study of the problems involved in stabilizing areas — outsiide the line of containment — which are threatened by Communism and insurgency. Discussions cover the changing approaches to foreign aid, relations of the Western powers, the roles of the Congress and State Department and other government agencies involved in foreign policy operations.

SS 464 World Politics: Problems of International Organization (3-0)3

International and regional organizations as mirrors of contemporary world politics and as forces of change. Study is made of the history and theories of international organization, the constitutional problems, and the structure and various functions of the United Nations Organization and other current bodies.

SS 471 The United States in World Politics (3-0)3

The backgrounds of American foreign policy and the various circumstances and conditions under which these principles have been applied by the United States are examined through case studies.

SS 472 Defense Policy (3-0)3

A study of the relationship of force and foreign policy in the thermonuclear age. Discussions cover organization and policy-making, military policy and strategy, and the substance of national security.

SS 477 Russia: The Empire (3-0)3

A study of the history of the Empire of the Tsars with special emphasis upon the economic, political, and social problems that led to the Revolution of 1917.

SS 478 Russia: The Soviet Union (3-0)3

A study of the history of the U. S. S. R. from 1917 to the present. The course will be divided into three general areas: Establishment of the Soviet state; the Stalinist period; and current domestic and foreign problems.

SS 479 The Far East Since 1842 (3-0)3

Nasic historical and cultural backgrounds of the peoples of East Asia surveyed as a preface to the study of the development of mainland and island states. Emphasis is given to American and European interest, policies, and relationships with China, Japan, and Korea.

SS 480 Modern China: 1644 to the Present (3-0)3

A study of developments in China's economic, political, and social evolution from the Manchu conquest to the Maoism of the 1960's. Emphasis will be given to China's foreign relations under the Manchus, during the "Nationalist" period, and since the advent of the Communist regime in 1949, as well as to "Red China's" role in Asian and global affairs today.

SS 481 or 482 The Greeks and Western Civilization (3-0)3

An examination of the contributions of the Greeks to our culture. The influences of Greek thought, art, and politics are studied in selected readings and discussions in seminar meetings.

SS 483 Political and Social Thought: The Greeks and the Romans (3-0)3

Studies in the works of the major writers of political and social philosophy from the origins of the Greek city-state into the decline of the Roman Empire. The relevance of early ideas to modern times will be stressed in class discussions.

SS 484 Political and Social Thought: 400 A. D. - 1600 A. D. (3-0)3

A study of the impact of Christianity on political and social ideas; the relation of ideology to institutions in the feudal period; and medieval ascetism and Renaissance individualism from St. Augustine through Machiavelli.

SS 485 Political and Social Thought: 1600 - 1800 (3-0)3

Puritanism, the Age of Science, and the Enlightenment; ideology from the Wars of Religion through the French Revolution; and the origins of modern conservatism and liberalism.

SS 486 Political and Social Thought: 1800 to the Present (3-0)3

The development of conservatism and liberalism since the Napoleonic Wars; Socialism, Communism, and Fascism; and the psychoanalytic and behavioral approaches to ideology.

SS 487 American Political Thought to 1865 (3-0)3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0)3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and wartime and post-war periods.

SS 492 Twentieth Century Germany (3-0)3

Political development, social and military history, and conflicts of the "-isms" in Germany from the founding of the Empire to West Germany's assumption of a position in the NATO Alliance. Relation of the nation's past to current problems of reunification, international position, and politics are studied though selected readings and discussions in seminar meetings.

SS 495 The Technological Future: The Material Aspects (3-0)3

Lectures and discussions forecasting the completely technologized society of 2000 A. D. The first semester emphasizes the nature of several "futuribles"—the possible futures — from the surprise-free environment to those involving scientific breakthroughs.

SS 496 The Technological Future: The Social and Political Aspects (3-0)3

Lectures and discussions during the second semester emphasize man's adaptation to the vast changes of the future and the probable nature of the future world civilization.

SS 499 Science and Religion: Science as a Social System (3-0)3

Consideration - through lectures and discussions - of the role of Science as a system of "Communication", in the contemporary sense in which that term is used in sociological, psychological, and communication-science studies. The latter

phase of the course will stress in preview the relations between Science and Religion as social systems.

SS 500 Science and Religion: Religion as a Social System (3-0)3

The course will emphasize the role of Religion as a system of "Communication", in the sense defined in the paragraph above for SS 499. The latter part of the course will emphasize the interconnections, both conflict and cooperation, between Science and Religion.

TEXTILES

TE 212 Fiber Science (3-1)3

The different fibers and their origin and properties. The effect of molecular arrangement in fibers upon the chemical, physical, and mechanical behavior of the raw material and upon their technological utilization. Polymer structure, order, intermolecular forces, flexibility, and other properties in the light of stress-strain relationships, such as viscoelastic behavior. These and other factors as design elements leading to the prediction of the physical properties of textile systems, as well as the geometry of yarns and fabrics and their behavior characteristics.

TE 264 Textile Systems I (3-1)3

The preparation into yarn of staple cellulosics and man made fibers on the cotton system as well as filamentous man made fibers. These are presented analytically in terms of engineering principles or mechanisms concerned with functional use, structural design, and basic geometry of the yarns.

TE 305 Textile Mechanism (3-0)3

A study of the basic principles of kinematics. Topics involved are rolling cylinders and cones, gearing, gear train design, epicyclic gear trains, flexible connectors including stepped pulley and cone design, cam design, linkages, and miscellaneous mechanisms. Available equipment serves as the basis of problems and assignments.

TE 311 Fiber Science (3-1)3

Available only to Juniors, Seniors, Graduate Students and with permission of the Department Head.

TE 335 Design and Analysis of Woven Structures (3-0)3

The communication of design techniques, construction and analysis of woven substrates as well as fabric identification. The effect of fiber, yarn, weave and texture on the carefully engineered and practical evolvement of the structures is stressed. The principles of yarn geometry and mechanical loom functions are correlated with the design and analysis.

TE 336 Fabric Technology I (2-2)3

This is designed to familiarize the student with the mechanism associated with single woven fabric production. Involved are the complexities of cams, kinetics, pulleys, cones, linkages, etc. as related to simple automatic looms and structures produced thereon.

TE 363 Textile Systems II (3-1)3
[TE 264]

Same as TE 264 but involving wool in woolen or worsted yarn systems or blends of same with natural and synthetic fibers. A consideration of recovery processes for use of waste in varied fabrics is included.

TE 365 Textile Systems III (3-2)3
[TE 264]

The concepts of fabric design: an analysis of the effects of mechanical processing upon structural relationships, with stress on physicomechanical and chemical behavior.

TE 366 Textile Systems IV (3-2)3
[TE 365]

A study of the more complex woven structures including jacquards, double fabrics, etc.

TE 411-412 Technology of Yarns I and II (2-2) (2-2)6

Designed to familiarize students with the basic machines and techniques for the production of yarns regardless of the fibers and/or production systems used. Primary emphasis is upon the mechanical principles employed.

TE 431-432 Fundamentals of Textiles — Fabrics I and II (2-2) (2-2)6

Designed to familiarize students with the basic machines and techniques for the production of fabrics regardless of the fibers and/or yarns employed, from the preparation of yarns for fabrication to the actions and modifications available for the production of fabrics. Primary emphasis is upon the mechanical principles employed.

TE 433 or 434 Technology of Knitting (2-2)3
[Recommended as technical elective for those majoring in textile engineering]

A broad survey of the mechanics of knitting equipment and the varied fabrics produced therefrom.

TE 437 Fabric Technology II (2-2)3
[TE 336]

A thorough study of design and weaving as applications of science to the construction of fabrics.

TE 457-458 Technology of Finishing I and II (3-0) (1-2)5

Lectures and laboratory workshop in the major engineering and chemical considerations necessary to convert greige fabrics to their finished state. Engineering aspects including heat transfer principles are stressed.

TE 459 Textile Systems V (2-1)2
[TE 366]

A study and analysis of the physical behavior of gray fabrics as mechanical systems during the finishing operations. Major emphasis is on absorption, pressure, heat transfer, and the physical and mechanical design principles involved.

TE 460 Textile Systems VI (1-2)2
[TE 459]

The basic chemical structure of the fibers within the fabric and the relationship which such a system has with the application of dye and finish due to chemical transition catalysis, electrostatic attraction, covalent and other bonding forces, etc., in effecting an acceptable end product.

TE 472 **Textile Evaluation** **(2-3)3**
[TE 363 or equivalent]

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equilibrium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 474 **Instrumentation for Textiles** **(2-2)3**
[PH 205 or equivalent]

A study of some mechanical, electrical, and electronic methods for the measurement and control of such common textile process variables as pressure, temperature, liquid level, and fluid flow. The response of sensing elements, the modes of control, the characteristics of final control elements, and the interrelationship between those in closed loop systems are considered.

TE 482 **Application of Scientific Methods to Textile Processes** **(3-0)3**
[PH 205, MA 206, ME 216]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483*-484* **Engineering Design of Textile Structures I and II** **(3-0) (3-0)6**
[MA 205, TE 363]

This subject correlates engineering properties of textile materials, engineering principles, and textile processing in the design of textile structures with desired properties. Graphical solutions are considered. The geometry of yarns, fabrics and wire cloth; design of textile structures for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes which the end use imposes; analyses of load-elongation diagrams of textile structural material.

TE 484* **Statistical Quality Control — Textile** **(3-0)3**
[MA 383, TE 363 or equivalent]

A study of statistical and administrative techniques relevant to the maintenance of product quality at defined levels. Sampling plans for variables and attributes are considered from the viewpoint of engineering economics.

TE 495 **Senior Project** **3**

This is an in-depth study or senior thesis on an acceptable topic and directed by a staff member.

TE 501-502 **Textile Polymer Science I and II** **(3-0) (3-0)6**
[Permission of Instructor]

The morphological, macromolecular, and molecular structure of fibers are considered as a basis for an understanding of various performance characteristics. The latter include stres-strain relationships in the non Hookian region, time dependent parameters primary and secondary creep, as well as the effect of environmental conditions on these parameters. Critical analysis of performance characteristics are used as a means of selection of fibers as structural units in the design of items having defined performance requirements. An introduction is made to the interrelation between fiber properties and yarn and fabric geometry in determining the behavior of textiles.

TE 503 **Technology of Novel Cellulosic Substrates** **(2-2)3**
[Permission of Instructor]

Systems for handling and methods of utilizing cotton waste products, modified cottons, non-woven textile structures in the production of novel fabrics. The effects of various chemical, mechanical and growth modifications of cotton on the chemical, physical and processing properties of cotton fiber. Problems are assigned for laboratory evaluations and a written report for oral presentation is required.

TE 517 **Product Quality** **(2-2)2**
[Permission of Instructor]

Product defects in the manufacture of spun yarns are studied and analyzed. Procedures necessary to avoid the defects are studied and the diagnostic ability of the student to recognize and remedy defects is developed with the aid of case histories.

TE 519 **Multifiber Processing: Yarns** **(3-2)3**
[Permission of Instructor]

The processing of man-made fibers into spun yarns using different yarn systems is studied with emphasis upon fiber and yarn properties and involving engineering principles. Blending techniques are covered for various fibers including both man-made and natural fibers.

TE 571 **Microscopy of Fibrous Materials and Assemblies** **(2-3)3**
[Permission of Instructor]

A consideration of the principles involved in the selection and use of appropriate optics as well as manipulative and preparative techniques for the qualitative and quantitative estimation of morphological, physical, and chemical properties of fibrous materials and assemblies. Observations are interpreted with the objective of eliciting information relevant to engineering applications.

TE 573 **Mechanical Testing of Textiles** **(2-3)3**
[Permission of Instructor]

Thickness and compressional measurements, stress-strain-time phenomena of viscoelastic textile materials. Vibroscope theory and techniques, yarn uniformity, thermal determination, and friction evaluation are among the major topics covered. Emphasis is placed on current literature search assignments and the preparation of a student paper on a selected topic within the scope of the subject.

TE 581 **Textile Management and Costing** **(3-0)3**
[Permission of Instructor]

Management principles and techniques applied to problems in textile administration; production, scheduling and routing; sales forecasting; inventory control; materials; machine and labor costing; budgeting; management recruiting and training; internal and external organization relations case histories used to supplement course coverage. Several textbooks available.

TE 583 **Textile Automation** **(3-0)3**
[Permission of Instructor]

Engineering approach to the study of the present auto-

mated textile manufacturing and production processes from fiber to finished fabric and their impact on management, labor, and cost factors. Research and problems relating to the degree of automaticity for better control of mass and flow production in the industry will be required and implemented with present trends.

TE 585 Textile Plants Organization — Yarns (3-0)3
[Permission of Instructor]

Designed to correlate the various aspects of yarn production. Emphasis is placed upon the need for proper balance among machinery elements for the production of specific yarn types. Consideration of machinery layouts for efficient and economic operation of the total yarn establishment, with stress on the various calculations involved. Considerable use is made of the case history technique of presentation.

TE 587 Textile Plants Organization — Fabrics (3-0)3
[Permission of Instructor]

Similar in concept to TE 585 except that the subject pertains to the production of fabrics.

TE 589 Central Management and Business Policies (3-0)3
[TE 581, Permission of Instructor]

New concept of managementation occurring in business today. Analytical framework for sifting and relating elements involved in the operational environment of the whole company; less reliance placed on intuitive grasp of factors affecting business policy formulation; the critical job of central management under this changing emphasis included as it affects various aspects of business case histories prepared, discussed and analyzed.

TE 592 Graduate Seminar (2-0)0

Introduction to thesis material and thesis preparation.

TE 593-594 Thesis Seminar Two hours per week
No credits

Required of all graduate students in Textile Technology. Devoted to problems in the preparation and presentation of research work, with illustrative material drawn from thesis work of the past and in process.

TE 595-596 Graduate Thesis Credits to be arranged

Each graduate student in Textile Technology is required to submit a thesis which shows ability and originality in the solution and presentation of a research project.

GRADUATE SCHOOL

INTRODUCTION

The Lowell Technological Institute Graduate School, founded in 1935, offers graduate programs in the following areas:

Master of Science Programs

Chemical Engineering
Chemistry
Chemistry - Polymer Science Option
Electrical Engineering
Mathematics
Paper Engineering
Physics
Textile Technology

Doctor of Philosophy Programs

Chemistry
 a, inorganic
 d. organic
 c, physical

Chemistry - Polymer Science Option

Physics
 a. solid state
 b. nuclear
 c. theoretical
 d. electron device
 e. atomic and hyperfine spectroscopy

Because of the varied objectives of the graduate students, each specific course of study is arrived at through consultation with the student's advisory committee.

ADMISSION

General Admission

To be eligible for admission to the Graduate School, an applicant must have received a bachelor's degree in an acceptable four-year course in which he has maintained a uniformly high scholastic rating. Both the quality and quantity of previous training are considered. Selection of applicants admit-

ted is based upon their ability to pursue graduate work of high quality.

Special Student Status

An applicant who meets the general admission requirements but who wishes to concentrate on specific subjects or special research programs may request special student status. Acceptance is contingent upon the consent of the instructor in charge of each subject to which admission is desired, and the work does not lead to a degree.

Normally a special student may not change his status to that of a student working for a graduate degree. If a special student wishes to work for a degree, he must apply in writing to the Director of the Graduate School. If the application for change in status is approved, all of the credit earned as a special student may not necessarily be allowed for degree credit.

Provisional Status

An applicant for admission who is unable to meet all the requirements for general admission may be accepted provisionally if he satisfies the department in which he wishes to enroll that he is probably able to pursue graduate studies successfully.

The status of a provisional graduate student may be changed to full graduate status upon demonstration of his ability to pursue graduate studies successfully as measured by the completion of his first semester's work with a minimum of a B-average in subjects taken for credit toward the graduate degree.

Application Procedure

Applications may be obtained from the Office of the Graduate School. They should be completed in duplicate and returned to the Director of the Graduate School not later than June 1 preceding the fall term in which the applicant wishes to enroll. Applications must be supported by letters from at least three persons qualified to judge the ability of the applicant to carry on graduate work and research. The letters, along with a carbon copy of each, should be sent directly from these persons to the Graduate School.

Two copies of all undergraduate records (and graduate, if any(must be sent directly to the Office of the Graduate School by the institutions which the applicant has previously attended. All transcripts must be official, with appropriate seals and signatures. Records, descriptions of subjects, and letters must be

in English. Each subject must be described in terms of content, scope, number of hours per week, and number of weeks duration. Lecture and laboratory time should be properly distinguished. If a catalogue giving such descriptions in English is available, the subjects taken may be clearly marked in a copy sent to the Graduate School.

Credit may be given for graduate subjects taken at other colleges if the grade received is at least B and if these subjects were not used in earning another degree at the same level. All applicants must submit two additional copies of transcripts which include the subjects for which transfer credit is desired, Not more than 10 credit hours for the master's degree or more than 22 credit hours for the doctor's degree may be transferred. No transfer credit can be offered for the thesis requirement for any graduate degree. Transfer credit for subjects take at other colleges before initial enrollment at Lowell Technological Institute must be cleared within four weeks after the student's first registration. No transfer credit for such subjects is given after this period.

In addition to returning two completed application forms and having transcripts and letters sent, the applicant must take the Graduate Record Aptitude Test and have the results sent to the Director of the Graduate School. Information regarding the Graduate Record Aptitude Test may be obtained from Educational Testing Service, 20 Nassau Street, Princeton, N.J., 08540 or Box 27896, Los Angeles, Cal. 90027, whichever office is nearer to the applicant. All fellowship and assistantship applicants must also take the appropriate Advanced Test administered by the Educational Testing Service.

Because most subjects are presented in lecture form, students from other countries should have a reasonably fluent command of the English language before applying for admission. All students from countries where English is not the national language must take the "Test of English as a Foreign Language" (TOEFL) examination administered by the Educational Testing Service. Information regarding the test may be obtained from TOEFL, Educational Testing Service, Princeton, New Jersey 08540, U.S.A.

Except in unusual circumstances, applications are acted upon and the applicant is notified of the decision by July 1. Foreign applicants are urged to apply as early as possible so as to leave enough time for visa and other arrangements to be made.

ACADEMIC EXPENSES

Tuition (per year)

U.S. citizens who are residents of Massachusetts $200

All others	$600

Graduate students carrying less than ten credit hours pay tuition according to the following schedule.

U.S. citizens who are residents of Massachusetts	$10 per credit hour
All others	$38 per credit hours
Student Activity and Insurance Fund (per year)	$49
Commencement Fee	$15

In addition, every graduate student is required to bear the cost of binding at least two copies of his thesis for the Institute's files. Some divisions may require more than two bound copies. Students are not permitted to register for thesis work until these fees have been paid at the library.

Graduate students who have previously registered for the number of thesis credits required for their degrees, but who, in order to complete their theses, must do further work requiring the use of laboratory facilities, must pay a tuition charge based on the number of credit hours determined in each case by the appropriate department head.

Graduate students who have completed all degree requirements except the writing and defense of a thesis, and who do not need to carry out further laboratory work to complete the thesis, must register for one credit hour of GS-600, Continued Matriculation.

CHANGES IN REGISTRATION

At the discretion and with the permission of the student's adviser, courses may be dropped, changed from credit to audit, audit to credit, graduate to undergraduate, undergraduate to graduate, etc., during the first four weeks of the semester. The course instructor's permission is not required, and the Director of the Graduate School's permission is arbitrarily stamped on the special action form, and a grade of W is recorded for any course dropped.

Changes in registration (dropping courses, changes between credit and audit or between graduate and undergraduate credit) after the period indicated above can be made only under unusual circumstances. These changes must be approved by the student's adviser, whose signature on the appropriate form indicates that the change is necessary due to illness or to circumstances beyond the student's control. If such a change is approved by the adviser, the course instructor's signature is necessary, together with assignment of a grade of WP or WF, depending on whether the student is passing or failing when the status of the course is changed. Final approval of such changes by the Director of the Graduate School is also necessary.

AFROTC

Graduate students who will have a minimum of two years remaining at the Institute may participate in AFROTC under the same conditions and with the same benefits as outlined on page 69 for the two-year AFROTC program.

FINANCIAL AID

Fellowships

No special applications are required, but students who wish to be considered for fellowships must have their completed graduate school application material, including transcripts and letters of reference sent to the Director of the Graduate School no later than April 1.

All fellowship applicants must take the appropriate Advanced Graduate Record Examination as well as the Aptitude Tests on or before the March examination date.

Teaching Assistantships

A limited number of part-time instructorships are available to qualified students working toward a graduate degree. Stipends are approximately $3000 per academic year, the exact amount depending on the nature of the appointment. Reappointment in succeeding years is contingent upon satisfactory performance of duties. Appointees are expected to carry up to a half-time teaching load, primarily involving supervision of undergraduate laboratories and review sections.

Research Fellowships

The Lowell Technological Institute Research Foundation sponsors a limited number of research fellowships for graduate study in certain fields. A stipend of $2500 plus tuition and fees is granted for one calendar year. The recipient carries a full graduate program during the fall and spring semesters and conducts his thesis investigation during the summer.

National Science Foundation Graduate Traineeships

The National Science Foundation has awarded grants to the Institute for the support of a limited number of Graduate Trainees in Physics. The Traineeships are awarded on the basis of ability. Candidates must be citizens of the United States on or before March 1 following the submission of their applications and must be admitted to full graduate status by the Institute

prior to beginning their Traineeship tenures. Grants may be extended to cover a three year period of doctoral studies.

The stipends provided by the NSF for Graduate Traineeships are $2400 for those on a tenure of twelve months and $1800 for those on a tenure of nine months. There is also an allowance of $500 for each dependent. Additional income for limited teaching activity up to $1000 is available. Tuition and fees are paid by the NSF directly to the Institute.

National Aeronautics and Space Administration Graduate Traineeships

The National Aeronautics and Space Administration has awarded a grant to the Institute for the support of a limited number of predoctoral Graduate Trainees in space related areas of Physics. The stipends and dependency allowance are virtually identical to the NSF Traineeships described above. Tuition and fees are paid by the NASA directly to the Institute.

Textile Salesmen's Association of New York Fellowship

A graduate fellowship in textiles is awarded by the Textile Salesmen's Association of New York, based on academic accomplishment and demonstrated ability. The award is limited to full-time students working toward the MS degree in Textile Technology who plan to continue working in the field of textiles in this country after graduation.

MASTER OF SCIENCE DEGREE PROGRAMS

CHEMICAL ENGINEERING

The graduate program in chemical engineering is designed to provide the opportunity for further studies in the fundamentals and application of chemical engineering principles and to carry out independent research work in the field of chemical engineering.

The Chemical Engineering Department will consider students for enrollment in the course of graduate studies who fulfill the requirements:

1. Students who have a Bachelor of Science degree in Chemical Engineering from a recognized school, or
2. Students who do not have a Bachelor of Science

degree in Chemical Engineering, but who have made up or will make up deficiencies in their training so that they can show proficiency equivalent to a Bachelor of Science degree in Chemical Engineering from Lowell Technological Institute.

Requirements for the M.S. Degree in Chemical Engineering

1. CN 501-502 Graduate Thesis up to **8 credits**

2. CN 530-531 Chemical Engineering Seminar (1-0) (1-0)2

3. A minimum of **12 credits** in chemical engineering subjects chosen from the following list.

4. A minimum of **9 credits** in technical electives chosen from the following list.

5. A minimum of **30 credits** in thesis, chemical engineering and technical electives is required to fulfill the requirements of a Master's Degree in Chemical Engineering.

Chemical Engineering Subjects

CN 407	Engineering Analysis of Chemical Processes	(3-0)3
CN 408	Engineering Materials	(3-0)3
CN 503 or 504	Absorption and Extraction	(3-0)3
CN 505 or 506	Colloid Chemistry for Chemical Engineers	(3-0)3
CN 507 or 508	Corrosion and Electrochemical Principles	(2-0)2
CN 509	Mathematics for Chemical Engineers	(3-2)4
CN 511 or 512	Structure and Properties of Matter	(3-0)3
CN 514	Advanced Economic Balance	(3-2)4
CN 517 or 518	Advanced Distillation	(3-0)3
CN 523 or 524	Advanced Chemical Process Analysis	(3-0)3
CN 525 or 526	Advanced Heat Transfer	(3-0)3
CN 532 or 533	Applications of Computers	(2-3)3
CN 534 or 535	Special Chemical Engineering Projects	(credits arranged)

Technical Electives

Any subject in chemistry in the 500 series.

Any subject in mathematics in the 300 series or higher.

MA 383 or 384	Statistical Methods	(3-0)3
EC 414	Engineering Economy	(3-0)3
ME 493 or 494	Industrial Instrumentation	(2-0)2

Thirty credits are required for the M.S. Degree, but additional undergraduate subjects may be required of students who have deficiencies in their prior training. Technical electives must be approved by the Head of the Department of Chemical Engineering and Paper Engineering.

CHEMISTRY

This program provides opportunity for advanced study and research training in chemistry, both general and specialized. Provision also is made for the student to elect certain advanced subjects in related fields of mathematics, physics, and engineering.

Evaluation Examination — During the aeek of registration each entering student must present himself for the four three-hour written evaluation examinations in the fields of organic chemistry, physical chemistry, inorganic chemistry, and analytical chemistry. These examinations are scheduled and administered by the Department of Chemistry, and the results serve as a guide for the student and advisory committee in planning the program of study. All entering students must take these examinations regardless of previous training.

Subject Requirements — Of the 20 credit minimum, exclusive of thesis and seminar, required in listed subjects (see Requirements for Graduation), a minimum of 15 credits must be taken in chemistry. The remaining credits (5 or more) may be taken in chemistry or in a related field such as physics, mathematics, or engineering. Credit is normally not allowed for undergraduate subjects in chemistry except for those so designated by an asterisk. Each graduate program in chemistry must include advanced subjects in organic chemistry, inorganic chemistry, and physical chemistry unless such requirements have previously been met. All students must take CH 507-508, Chemistry Seminar.

Although the design of the student's program is the res-

ponsibility of the advisory committee, the following listing provides a suggested core of subjects:

Chemistry - First Semester Subjects

CH 431*	Advanced Physical Chemistry	(3-0)3
CH 507	Chemistry Literature	(1-0)1
CH 516	Chemical Literature	(1-0)1
CH 523	Organic Reaction Mechanisms and Structure	(3-0)3
CH 541	Graduate Thesis	5
CH 543	Modern Inorganic Chemistry	(3-0)3

Chemistry - Second Semester Subjects

CH 432* (1)	Advanced Physical Chemistry	(3-0)3
CH 508	Chemistry Seminar	(1-0)1
CH 515	Advanced Laboratory Technique	(1-3)2
CH 524 (1)	Organic Synthesis	(3-0)3
CH 542	Graduate Thesis	5
CH 544 (1)	Modern Inorganic Chemistry	(3-0)3

(1) Although the student must take both semesters of the advanced subject in the field of his major, he may substitute 3 - 6 credits of the other two advanced subjects listed with an approved elective either in his first or second year. Students wishing to go on for the Doctorate should plan to take both semesters in all three fields (excepting for Polymer Science Option).

The department also offers a Polymer Science Option in the M.S. program. This program has the following subject requirements:

Polymer Science - First Semester Subjects

C 431*	Advanced Physical Chemistry	(3-0)3
CH 503	Chemistry of High Polymers	(3-0)3
CH 505	Techniques of Polymer Chemistry	(0-4)1

CH 507	Chemistry Seminar	(1-0)1
CH 509	Introduction to Polymer Physics	(2-0)2
CH 523	Organic Reaction Mechanisms and Structure	(3-0)3
CH 541	Graduate Thesis	5

Polymer Science - Second Semester Subjects

C 432* or CH 524 or CH 544 (see Chemistry Program)		(3-0)3
CH 504	Chemistry of High Polymers	(3-0)3
CH 506	Techniques of Polymer Chemistry	(0-4)1
CH 508	Chemistry Seminar	(1-0)1
CH 510	Introduction to Polymer Physics	(2-0)2
CH 542	Graduate Thesis	5

Language Requirements — The student must demonstrate his ability to read technical German. For details concerning the language examination, see the section on Doctor of Philosophy Degree Program.

Advisory Committee — Shortly after registration in the graduate program the student is assigned an advisory committee consisting of a chairman pro tem and two other members of the graduate faculty in chemistry. The committee is appointed by the Director of the Graduate School upon the recommendation of the Division Chairman. The chairman pro tem is subsequently replaced by the thesis supervisor. The advisory committee has the following duties:

1. The development of an academic program consistent with the student's background and specific interests and with basic degree requirements.
2. Evaluate the student's performance and potential through periodic conference, recommend the degree program for which he appears to be best equipped, and where performance is below graduate school standards, recommend dismissal.
3. Advise and assist the student both throughout the course of his research and in the preparation of the thesis.

Thesis Examination — Each candidate for the Master of Science degree in Chemistry must present himself for an oral examination in the field of his thesis before an examining committee appointed by the department head from the graduate faculty in chemistry. This examining committee normally will not include the student's advisory committee. The chairman for the examination shall be the head of the department or his designate. While only members of the examination committee and the Director of the Graduate School may conduct the examination, all faculty members may attend. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the last semester. Each student has the right to one re-examination within a period of one year.

ELECTRICAL ENGINEERING

The graduate program in electrical engineering is designed to provide the opportunity for the student to broaden and deepen his knowledge and to develop a more scholarly approach to the solution of problems in electrical engineering.

A core curriculum consisting of four 3-semester hour courses is required of all students who are pursuing the degree of Master of Science in Electrical Engineering. The core curriculum consists of two 3-semester hour courses in systems analysis (EE 509-510) and two 3-semester hour courses in applied mathematics (MA 533 and MA 484). These courses are designed to give the student a solid foundation in the techniques of modern analysis.

A minimum of 18 additional semester hours are required of all students who are pursuing the Master's degree. A student is expected to elect a sequence of courses from one or more of the advanced areas of specialization in electrical engineering. The program of each student will be arranged and approved by an advisor assigned to him by the department.

A number of courses are being offered through the Division of Evening Studies for the purpose of providing part-time graduate study in electrical engineering. These courses in noway differ from those currently being offered to students in the full-time day program. These courses allow a part-time student to progress in accordance with his available time.

The admission and degree requirements are the same for part-time students.

Basic Curriculum

EE 509	Systems Analysis - Transformation	(3-0)3
EE 510	Systems Analysis - State Variables	(3-0)3
MA 464	Probability	(3-0)3
MA 533	Matrix Analysis	(3-0)3

Controls and Simulation

EE 401-402 (3-0)6	Feedback Control Systems and their Components(3-0)	
EE 423	Analog Computer Technology	(1½-1½)3
EE 511-512	Dynamic Control Analysis	(3-0) (3-0)6

Computer Sciences

EE 411-412	Logical Design of Digital Computers	(3-0) (3-0)6
EE 445-446	Analog and Digital Devices and Techniques	(3-0) (3-0)6
EE 521	Automata Studies	(3-0)3

Communication Theory

EE 433-434	Electro-Optical Analogs	(3-0) (3-0)6
EE 437-438	Introduction to Optical Information Processing	(3-0) (3-0)6
EE 441-442	Systems Engineering	(3-0) (3-0)6
EE 547	Statistical Communication Theory	(3-0)3
EE 548	Information Theory	(3-0)3

Circuit Theory

EE 415-416	Electronic Amplifier Circuits	(3-0) (3-0)6
EE 425-426	Waveshaping and Generation	(3-0) (3-0)6
EE 529-530	Network Synthesis	(3-0) (3-0)6

Solid-State and Quantum Electronics

EE 503-504	Solid-State Physical Electronics	(3-0) (3-0)6
EE 533-534	Special Problems in Electronics	(credits arranged)

Electromagnetic Fields

EE 501-502	Applied Statistics	(3-0) (3-0)6
EE 505-506	Microwave Electronics	(3-0) (3-0)6
EE 507	Electromagnetics	(3-0)3

MATHEMATICS

The graduate program in mathematics is designed to provide a sound background for a variety of career interests, including academic and industrial research, development and teaching.

Each student admitted to graduate study will be assigned an advisor to supervise the preparation and periodic revision of his plan of study, and to assist him in successfully completing the requirements for the degree.

Prerequisites — An applicant for admission to graduate study in mathematics is expected to have an adequate preparation in mathematics. It is recognized that today there are wide variations in the content and scope of undergraduate programs; however, a reasonable minimum preparation will consist of (a) two or three years study of the calculus and allied topics, including at least a semester of what is generally known as advanced calculus, or introductory real analysis, and (b) a mastery of the basics of either modern linear algebra or abstract algebra. A student deficient in these areas may be required to follow certain additional courses during his first year of study.

Plan of Study — Each student's program of activity is formulated by him in consultation with his advisor, and must receive departmental approval. The basic plan of study should represent a reasonable broad selection from the area of analysis, algebra, geometry/topology, and applied mathematics. Mathematics course offerings in combination with those of other science and engineering departments make possible graduate programs with various degrees of emphasis in either pure or applied mathematics.

In addition to breadth, the student's program should lead to a certain depth in an appropriate direction. This may be implemented by a two or three semester sequence of course work in a particular subject, combined with a suitable amount of independent study and research.

The list of courses which carry graduate credit, together with their descriptions, may be found in the Mathematics section of the General Catalogue.

Thesis — Normally a satisfactory thesis is required, the subject and scope of which must be approved by the student's advisor and the department. The thesis shall give evidence of independent investigation on a topic of significance, and forms an important part of the student's program. It must satisfy the requirements of composition and style specified by the Graduate School.

Oral Defense — Upon completion of his thesis, each candidate for the Master of Science Degree must present himself for an oral examination in the field of his thesis work to an examination committee. This committee is appointed by the department head, and is comprised of the student's advisor, together with other appropriate Institute staff members, usually two in number.

Comprehensive Examination — Normally upon completion of their first year of graduate study (or the equivalent thereof, which is 15-18 credit hours of course work), all students must pass a comprehensive examination. This examination is designed to test the student's understanding of the basic concepts and results in the major areas of mathematics. The content and format of the examination is determined by the department in consultation with the student's advisor, and may be oral or written or both.

Residence — No specific residence requirements are specified by the department in addition to those contained in the general Graduate School regulations.

Foreign Language — A reading examination in modern foreign languages is not a formal requirement for the master's degree. However, any student who expects to do further graduate work in mathematics is most strongly advised to gain practice in reading the current mathematical literature in either French, German or Russian.

PAPER ENGINEERING

This program provides for advanced study and research training in paper engineering and allied subjects, with specific application to the paper industry.

The Paper Engineering Department will consider applicants in the following categories:

1. Graduates of the Lowell Technological Institute paper engineering program.
2. Graduates in paper engineering of paper technology from other universities.
3. General B.S. or M.S. graduates in engineering or chemistry with no previous training in paper engineering.

Requirements for the M.S. Degree in Paper Engineering

1. PA 501-502 Graduate Thesis up to **8 credits**
2. PA 534 or 535 Special Paper Projects (credits arranged)
3. PA 530-531 Paper Engineering Seminar (1-0) (1-0)2
4. A minimum of **12 credits** in paper engineering subjects chosen from the following list.
5. A minimum of **9 credits** in technical electives chosen from the following list.
6. A minimum of **30 credits** in thesis, paper engineering and technical electives is required to fulfill the requirements of a Master's Degree in Paper Engineering.
7. Additional undergraduate subjects may be required of students who have deficiencies in their prior training. Technical electives must be approved by the Head of the Department of Chemical Engineering and Paper Engineering.

Paper Engineering Subjects

PA 503-504	Advanced Converting Processes	(3-0)	(3-0)6
PA 505	The Physics of Paper		(3-0)3
PA 506	New Techniques in the Paper Industry		(3-0)3
PA 508	Advanced Paper Systems Analysis		(2-0)2
PA 509 or 510	Economics of the Paper Industry		(2-0)2
PA 512	Advanced Fiber Processing		(3-0)3

Technical Electives

Any subject in chemistry in the 500 series.
Any subject in chemical engineering in the 500 series.

CN 407	Engineering Analysis of Chemical Processes	(3-0)3
CN 408	Engineering Materials	(3-0)3
EC 414	Engineering Economy	(3-0)3
MA 383 or 384	Statistical Methods	(3-0)3
ME 493 or 494	Industrial Instrumentation	(2-0)2

PHYSICS

The graduate programs in physics provide an opportunity for advanced study and development of research capacity in physics. The laboratories of the department are well set up for investigations in crystal physics, and other aspects of solid-state physics, with excellent equipment in X-rays, spectroscopy, and electron microscopy. Equipment in nuclear physics is constantly being added.

Subject Requirements — Of the 20-credit minimum, exclusive of thesis, required in listed courses (see Requirements for Graduation) 15 credits must be taken in physics. The remaining credits (five or more) may be taken in a related field. Of the total credits at least 12 must be in subjects numbered 500 and above. A reasonable and consistent program of study is prepared by the student and his advisory committee. This committee consists of two or more members from the faculty of the Division of Physics and Engineering Science, one of whom is the thesis supervisor. The committee is appointed by the department head. Entering students who are found to be deficient in any areas of the undergraduate curriculum in physics may be required to take appropriate courses in that curriculum.

Language Requirements — The student must demonstrate his ability to read technical German or Russian.

Thesis Examination — Each candidate for the Master of Science Degree in this department, upon completion of his thesis, must present himself for an oral examination in the field of his thesis to an examination committee appointed by the department head and consisting of his advisory committee and other appropriate faculty members. The examination is held after the thesis has been accepted and within a period of two

weeks prior to the close of the final semester. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the last semester. Each student has a right to one re-examination within a period of one year.

TEXTILE TECHNOLOGY

This graduate program is offered to qualified students in the field of textiles, with primary emphasis upon either the engineering or physical aspects of the field. Ample opportunity is afforded for study and research in the physical and mechanical properties of fibers and textile structures and methods of evaluating them. Work at an advanced level on the structural design of textiles, processing principles, and manufacturing equipment is also available. Applicants should have a B.S. degree in Textile Engineering or Technology, Mechanical Engineering, or Electrical Engineering. Applicants with degrees in other areas, however, are given consideration.

Diagnostic Examinations — All entering students who have had previous training in textile technology are required to take diagnostic examinations during registration week. The subject areas tested are Fundamentals of Yarns, Fundamentals of Fabrics, Finishing Statistics, and Statistical Quality Control. Students are required to take diagnostic examinations only in subjects in which they have had previous training. Those who demonstrate proficiency in diagnostic examinations are exempt from taking the corresponding subjects during their program at the Institute.

Subject Requirements — The following suggested curriculum is recommended for most students. Those who demonstrate proficiency in diagnostic examinations are exempt from taking the corresponding subjects. Students whose background is deficient in engineering or mathematics are required to take additional subjects. All undergraduate deifciencies must be cleared prior to acceptance into any graduate subject.

First Semester

MA 383	Statistical Methods	(3-0)3
TE 311	Fiber Science	(3-1)3
TE 411	Technology of Yarns I	(2-2)3
TE 431	Fundamentals of Textiles - Fabrics I	(2-2)3

TE 433	Technology of Knitting	(2-2)3
TE 457	Technology of Finishing	(3-0)3
	Total hours	(15-7)18

Second Semester

TE 412	Technology of Yarns II	(2-2)3
TE 432	Fundamentals of Textiles - Fabrics II	(2-2)3
TE 458	Technology of Finishing	(1-2)2
TE 472	Textile Evaluation	(2-3)3
TE 474	Instrumentation for Textiles	(2-2)3
TE 592	Graduate Seminar	(2-0)0
	Total hours	(11-11)14

Third Semester

TE 483*	Engineering Design of Textile Structures I	(3-0)3
TE 501	Textile Polymer Science I	(3-0)3
TE 593	Thesis Seminar	(2-0)0
TE 595	Graduate Thesis	3
	Electives	6
	Total credit hours	15

Fourth Semester

TE 484*	Engineering Design of Textile Structures II	(3-0)3
TE 502	Textile Polymer Science II	(3-0)3
TE 594	Thesis Seminar	(2-0)0
TE 596	Graduate Thesis	3
	Electives	6
	Total credit hours	15

*May be taken for graduate credit.

Electives are to be chosen from those available in any one semester from the 500 series of textile subjects.

Electives are arranged in blocks and no two will be chosen from the same block in any one semester.

Although most electives will end in an odd digit, it may be available in either semester.

Thesis Examination — Each candidate for the Master of Science Degree in Textile Technology, upon completion of his thesis, must take an oral examination in the field of his thesis. This examination is conducted by a committee appointed by the Director of the Graduate School which must include the thesis supervisor and advisers of the candidate and any additional faculty members desired by the Director. Any faculty members may attend, but only members of the examination committee may conduct the examination. The examination is held after the thesis has been accepted and within a period of two weeks prior to the close of the semester in which the student expects to be a candidate for the degree. Application to take the examination must be filed by the student with the department head at least one month prior to the close of the designated semester. If the student fails the oral examination, he has the right to one re-examination within a period of one year. Failure in the re-examination requires the satisfactory completion of a new thesis subject and the accompanying oral examination.

MASTER OF SCIENCE DEGREE REQUIREMENTS

Term of Residence — Applicants with sufficient background in their chosen field of concentration normally require one to two academic years of residence to complete the requirements for the Master's degree. Those with minimum background require a minimum of two years of residence.

Graduates of other colleges usually need more than one academic year to fulfill the degree requirements, even though they majored as undergraduates in their graduate field of specialization.

All requirements for the master's degree must be completed within five years after the student's entrance. Extension of time beyond this limit may be granted only with joint approval of the student's adviser (or advisory committee), his department head, and the Director of the Graduate School.

Requirements for Graduation — To be recommended for the Master of Science degree a candidate must satisfy the requirements of The Graduate School and of the department in which he is enrolled. The requirements of The Graduate School are given below, and additional requirements established by

various departments may be found in the section giving departmental programs.

A candidate for the degree of Master of Science must:

1. Complete a course of study approved by the department in which he is enrolled and which is subject to review by The Graduate School. The approved course of study must have a minimum of 30 credit hours of graduate work including credits given for a thesis or project in the student's chosen field. A minimum of 18 credit hours must be spent in listed subjects, and it is normally expected that the program should have a maximum of 12 credit hours for original research and no more than 3 credit hours for other investigations.
2. Complete a Masters' thesis, which must be based on the results of original research, or a Masters' project, which will consist of other scholarly investigation such as a review, report, synthesis or design in the student's field. The thesis or project must be presented in clear and precise language and must be approved by the department in which the student is enrolled. A thesis reporting the results of original research must conform to the format specified in the Thesis Guide, which is available in the Graduate School Office. The only grades given for thesis work are S (satisfactory) and U (unsatisfactory), and all theses should be submitted in final form to the candidate's adviser on or before May 15 in order to receive the degree at June Commencement. Two copies of the thesis or project abstract must be filed in the Graduate School Office irrespective of whether the thesis deals with original research or not.
3. Successfully pass any oral or written examinations on his complete Master,s program that the department may require. It is normally expected that a candidate completing original research will pass an oral examination dealing mainly with his research problem and that candidates completing other investigations will pass an examination more comprehensive in nature.

4. Maintain residence for at least one academic year. Maintain at least a B- average in all work in formal subjects offered for the degree. The lowest grade accepitable for graduate credit is C. All undergradu-

ate subjects taken to clear deficiencies in the student's preparation for graduate work, but which, are taken during his enrollment as a graduate student must be passed with a grade of at least C; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgement of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.

6. Fulfill departmental language requirements.
7. Satisfy all requirements as to tuition and fees.

DOCTOR OF PHILOSOPHY DEGREE PROGRAMS

CHEMISTRY

Objectives

The doctoral program in chemistry is designed to provide the student with a background in advanced course work and chemical laboratory techniques that will prepare him to carry out, under the guidance of experienced scientists, an original, independent investigation that will lead to an acceptable contribution to the body of contemporary chemical knowledge.

Plan of Program

The doctoral degree normally requires from three to four years study beyond the bachelor's degree or a minimum of two to three years beyond the master's degree.

The plan of study pursued by each student is dependent on individual requirements and is developed through conference with his advisory committee or, pending its appointment, with his temporary adviser.

All students entering the doctoral program must take the complete set of evaluation examinations given during the week of registration as described in the section relating to the Master of Science program in chemistry. Only those students who have taken these examinations previously as candidates for the Master of Science program will be excused.

The initial part of the student's program, normally completed at the end of two years of study, is devoted to formal course work. His first year is usually given to subjects in the

major branches of chemistry in preparation for his qualifying (candidacy) examinations. The second year is devoted primarily to advanced subjects in a special field of concentration in preparation for the comprehensive examinations.

The second and final part of the program is devoted principally to research leading to the doctoral thesis. However, the student is encouraged to begin research as early as possible in his program of study.

Upon entrance to the doctoral program, each student is assigned an advisory committee. This committee is appointed by the Director of the Graduate School, based upon recommendation by the Chairman of the Division of Chemistry and Applied Chemistry, and consists of three members of the graduate faculty in chemistry. One member of the committee representing the student's major field of interest serves as temporary chairman. After the student has selected his thesis supervisor, the temporary chairman of the advisory committee is replaced by the thesis supervisor, who then serves as permanent chairman.

The committee is responsible for the development of the student's program, for advising the student throughout the course of his research and in the preparation of his thesis, and for conducting the oral examination in defense of the proposition. It moreover has the prerogative of maintaining continuing surveillance over the aptitude and performance of the student under its direction through periodic conferences, and should it find that the student's capability and potential are below Doctoral standards it may recommend to the Department Head that the student transfer to the Master of Science program or if circumstances warrant, be dismissed.

Examinations for Doctoral Students in Chemistry

Qualifying Examinations — Examinations are given by the Department of Chemistry in the fields of organic chemistry, physical chemistry, inorganic chemistry, and analytical chemistry. Before the student can be admitted to candidacy for the doctorate, he must pass all examinations.

Qualifying examinations are offered in all fields in September during the week of registration and in June following the examination period. All four qualifying examinations must be attempted not later than the beginning of the third semester of graduate study in the doctoral program (normally in September of the second year), though any one or all may be attempted earlier. In cases of failure, re-examinations may be taken only during the June period. A second failure in any one of the examinations results in automatic dismissal from the doctoral program. All qualifying examinations must be passed before

the beginning of the third year in the program. Any examination not taken within the schedule prescribed above will be considered as failed.

Comprehensive Examinations — The comprehensive examination consists of two parts: a written examination and the oral defenses of a proposition. The written examination is scheduled for one full day and encompasses the entire field of the major. It is given in September during the week of registration. It should be taken as soon as possible after completion of the bulk of course work in listed graduate subjects in the field of specialization. However, it must be taken not later than the beginning of the fourth year of study in the doctoral program. Where it is necessary to carry less than the normal credit load of 12 per semester, the student must apply for extension beyond this deadline to the chairman of the division through the chairman of his advisory committee.

The oral examination on the proposition is directed primarily to the research topic submitted but may include relevant background material.

The proposition represents a thesis in miniature without laboratory work. With the aid and advice of his advisory committee the student selects a subject suitable for investigation, completes a literature survey, outlines the method of approach, and suggests possible results and conclusions. He is then required to defend his proposition by oral examination. The examination. The examination is conducted by the student's advisory committee and with other faculty members of the department in attendance.

Prior to the oral examination and at least one month before the scheduled date of the written comprehensive examination, the student must file with the chairman of his advisory committee three written copies of his proposition, presented in the form generally prescribed for a thesis. The oral defense of the proposition is presented after the written comprehensive examination, and permission to take the oral examination is contingent on first passing the written test.

The request to take both qualifying and comprehensive examjnations must be initiated by the student. The request is made to the advisory committee, and the chairman of that committee then submits a written recommendation to the division chairman that the examination be given. The examination schedule is published well in advance of the date set, and the student must file the request with his advisory committee at least one month before the scheduled date. The deadline normally is 5 P.M., May 1, for the June examinations and 5 P.M. on the last day of classes in the second semester for the September examinations.

Thesis Examination — Upon completion of his doctoral research, the candidate must present himself for oral examination on his thesis. Permission to take this examination must be sought through the advisory committee chairman to the division chairman and is granted only after all candidacy requirements have been met and the comprehensive examinations passed.

The examination is conducted by three members of the graduate chemistry faculty who shall be appointed by the department head. Normally the examing committee will not include members of the student's advisory committee. The chairman for the examination shall be the department head or his designate.

Language Examinations — A candidate for the doctorate must demonstrate by examination ability to read technical literature in two foreign languages. One foreign language must be German. The second language is generally French or Russian. Proficiency in English is a requirement for foreign students, and the department reserves the right to establish this proficiency by examination if such action is indicated.

Language examinations are scheduled in November and in March. The student must present himself for examination in at least one language at each scheduled examination period until the complete language requirement has been fulfilled.

Course Offerings and Distribution

As a basis for the candidacy examinations the following core of subjects is recommended for the first-year students in the doctoral program:

CH 431-432*	Advanced Physical Chemistry	(3-0)	(3-0)6
CH 515	Advanced Laboratory Technique		(1-3)2
CH 516	Chemical Literature		(1-0)1
CH 523	Organic Reaction Mechanism and Structure		(3-0)3
CH 524	Organic Synthesis		(3-0)3
CH 543-544	Modern Inorganic Chemistry	(3-0)	(3-0)6
CH 564	Organic Qualitative Analysis		(1-6)3

If the results from the diagnostic examinations indicate adequate background in any of the above subjects, substitution by a more advanced subject in the 500 series is recommended.

Additional subjects in chemistry or in the field of the minor

may be taken in the first year if desired, provided the prerequisites are met.

In the second year, subjects supporting concentration in specific fields are available as follows:

Organic Chemistry

CH 521-522	Physical Organic Chemistry	(3-0)	(3-0)6
CH 527-528	Stereochemistry	(3-0)	(3-0)6
CH 553	Organic Chemistry of Macromolecules		(3-0)3
CH 554	Stereochemistry of Macromolecules		(3-0)3
CH 561-562	Advanced Organic Synthesis	(3-0)	(3-0)6
CH 565	Heterocyclic Chemistry		(3-0)3
CH 568	Structural Analysis		(3-0)3

The core of subjects recommended for majors in organic chemistry includes CH 521-522, CH 527-528, and CH 561-562. Majors in organic chemistry must also meet a requirement in physical chemistry comprising the course sequence CH 539-540.

Physical Chemistry

CH 531-532	Statistical Mechanics for Chemists	(3-0)	(3-0)6
CH 533-534	Quantum Mechanics for Chemists	(3-0)	(3-0)6
CH 535-536	Advanced Topics in Physical Chemistry	(3-0)	(3-0)6
CH 537	Chemical Thermodynamics		(3-0)3
CH 539	Theoretical Chemistry		(3-0)3
CH 540	Chemical Kinetics		(3-0)3

Chemistry Seminar

During each year of residence the student is required to attend and to participate in CH 507-508, Chemistry Seminar, (1-0) (1-0)2.

Majors and Minors

The prospective candidate, may supplement his training in the major field of interest by electing a minor. The minor should represent a minimum of 12 credits and may be divided between two fields of study. The minor program may be selected from chemistry subjects outside the major field of interest, as well as from approved advanced subjects in physics, mathematics, or engineering.

CHEMISTRY-POLYMER SCIENCE OPTION

Objective

Students in the PhD program in Chemistry may elect an option in Polymer Science. This optional program is designed to provide both knowledge in depth of the special physical and chemical behavior of macromolecular substances and a sound background in physical and organic chemistry to serve as a foundation for research training and experience in high polymers.

Plan of Program

The program is similar to that in chemistry except that increased emphasis is placed on subjects in the field of specialization.

It is recommended that the first year student take the following subjects:

CH 431-432*	Advanced Physical Chemistry	(3-0)	(3-0)6
CH 503-504	Chemistry of High Polymers	(3-0)	(3-0)6
CH 505-506	Techniques of Polymer Chemistry	(0-4)	(0-4)2
CH 523	Organic Reaction Mechanisms and Structure		(3-0)3
CH 524	Organic Synthesis		(3-0)3

The core of subjects recommended for the second and third year follows:

CH 509-510	Introduction to Polymer Physics	(2-0)	(2-0)4
CH 516	Chemical Literature		(1-0)1
CH 521-522	Physical Organic Chemistry	(3-0)	(3-0)6
CH 527-528	Stereochemistry	(3-0)	(3-0)6

CH 539	Theoretical Chemistry	(3-0)3
CH 540	Chemical Kinetics	(3-0)3
CH 549	Physical Chemistry of Macromolecules I. Theory	(3-0)3
CH 551	Physical Chemistry of Macromolecules II. Methods	(3-0)3
CH 553	Organic Chemistry of Macromolecules	(3-0)3
CH 554	Stereochemistry of Macromolecules	(3-0)3

Recommended electives include CH 531-532, Statistical Mechanics for Chemists; CH 538, Rheology; and MA 433* or 434* Matrix Algebra.

Examinations for Doctoral Students in Chemistry-Polymer Science Option

The examination system is the same as described for the doctoral degree in chemistry with the following exceptions:

(a) Evaluation examinations required upon entrance to the program shall involve only organic chemistry, physical chemistry and analytical chemistry. An evaluation examination in polymer science is offered to those who wish to be exempted from CH 503-504 and/or CH 509-510.

(b) Qualifying examinations are required in the fields of polymer science, organic chemistry, physical chemistry, and analytical chemistry.

(c) The comprehensive examinations, both written and oral shall be in polymer science.

REQUIREMENTS FOR PH.D. DEGREE IN CHEMISTRY AND POLYMER SCIENCE OPTION

Term of Residence — Only work done during the regular academic year from September to June is counted toward residence credit. A minimum of one full academic year of study in residence is reuuired of all candidates. A full year constitutes not less than 24 credit hours of work. Semesters in residence should be consecutive if possible.

All requirements for the doctorate must be completed within seven years after the student's entrance and within four years after admission to candidacy. Extension of time beyond this limit may be granted only with the joint approval of the student's advisory committee, his department head, his division chairman, and the Director of the Graduate School.

Candidacy for the Doctorate in Chemistry and Polymer Science Option — To be admitted to candidacy for the doctorate, a student must:

1. Complete the first year's core of recommended subjects and have a satisfactory record in undergraduate training, graduate seminar, and collateral reading.
2. Pass the qualifying examinations which test his genera knowledge. One day each is devoted to an examination in the following areas: organic chemistry, physical chemistry, and combined inorganic-analytical c emistry.
3. Fulfill the language requirements.
4. Secure the approval of his advisory committee and the division chairman.

When these requirements have been fulfilled, the division chairman notifies the Director of the Graduate School in writing and recommends that the student be placed on the list of candidates for the Ph.D. degree. Admission to candidacy in no way guarantees the granting of the degree.

Requirements for Graduation — To be recommended for the Doctor of Philosophy degree in Chemistry and Polymer Science Option a candidate must:

1. Satisfy the residence requirements.
2. Pursue an approved program of study that includes the satisfactory completion of at least 90 credit hours beyond the bachelor's degree, or equivalent. At least half of these credits must be in formal course work exclusive of seminars or thesis.
3. Maintain at least a B- average in all work in formal subjects offered for the degree. The lowest grade acceptable for doctoral credit is C-. All undergraduate subjects taken to clear deficiencies in the student's preparation for graduate work but which are taken durin r his enrollment as a graduate student must be passed with a grade of at least C-; however, these do not enter into the determination of his graduate scholastic rating. A graduate student's record is reviewed periodically, and if at any time, in the judgement of the Director of the Graduate School, the student is not maintaining the scholastic standards required, he may be asked to withdraw from the Institute.
4. Demonstrate satisfactory reading ability in German and ne other language (preferably French or Russian) Foreign students may under certain circumstances sudstitute their native tongue for one of these languages. Both language examinations must be passed

prior to advancement to candidacy and before extensive work on the thesis is begun.

5. Pass the qualifying examinations for candidacy.
6. Pass the major examinations in the field of concentration. These examinations primarily test the student's knowledge in his special field of concentration and draw heavily on knowledge gained during his second full year of study in that particular area. They are given only when substantially all of the formal course work has been completed, normally at the end of the second full year (fourth semester). The major examination is in two parts. The first part is written and extends over a period of one day. It tests the student's broad knowledge in his specific field. The second part of the major examination is oral and tests the student's aptitude for researc and his ability to organize and to develop a research problem. The examination takes the form of the defense of a proposition. The student selects a problem with the approval of his advisory committee.
7. Complete a satisfactory thesis. The doctoral thesis is designed to permit the student to demonstrate his ability to conduct original and independent research work. Results of the thesis investigation should constitute a definite contribution to knowledge in the field of specialization and should be suitable for publication. The field of the thesis investigation should be selected as soon as possible after admission to the graduate program, and the subject of the thesis must be approved by the advisory committee. As soon as the subject has been selected, the student must make his choice known to the department head, who in turn notifies the Graduate School so that the list of theses in progress may be kept current. The thesis subject must be filed not later than two weeks after the student has been admitted to candidacy. The thesis normally constitutes about half of the total credit requirement and, as a rule, requires three to four semesters of full-time work.
8. Pass a thesis examination. This is an oral defense of the studen 's thesis before the faculty of the Department of Chemistry.

   Satisfy all requirements as to tuition and fees.

Physics

A research program in both theoretical and experimental physics leading to the degree of Doctor of Philosophy in Physics is offered in the following fields: Theoretical Physics, Solid-State Physics, Nuclear Physics, Electron Device Physics, and Atomic and Hyperfine Spectroscopy.

Objectives

The doctoral program in Physics is designed (a) to provide the student with a thorough training in classical and modern physics and (b) to advance the student to the level where he can successfu ly carry out independent experimental and theoretical work in problems of modern-day physics.

Plan of Program

An incoming graduate student is assumed to possess a sound background in intermediate-level mechanics, electricity and magnetism, statistical mechanics, thermodynamics, and modern physics. Accordingly, a typical graduate curriculum would be drawn from the following subjects:

First Year

MA 505-506	Mathematical Methods of Physics	(3-0)	(3-0)6
PH 471-472	Solid-State Physics	(3-0)	(3-0)6
PH 511	Classical Mechanics		(3-0)3
PH 515-516	Quantum Mechanics	(3-0)	(3-0)6
PH 521	Statistical Mechanics		(3-0)3
PH 557-558	Electricity and Magnetism	(3-0)	(3-0)6

Second Year

PH 537	Group Theory		(3-0)3
PH 561	Nuclear Physics		(3-0)3
PH 575-576	Problems in Solid-State Physics	(3-0)	(3-3)7
PH 593-594	Graduate Laboratory		(credits arranged)

Third and Fourth Years

PH 517	Advanced Quantum Mechanics	(3-0)3
PH 519	Theory of Weak Interactions	(3-0)3
PH 555	Plasma Physics	(3-0)3

PH 583-584	General Theory of Relativity	(3-0) (3-0)6
PH 601-606	Special Problems	(credits arranged)
PH 701-706	Research	(credits arranged)

Subjects marked with a dagger (†) are ordinarily required and may be waived for the incoming student only at the discretion of the department head. A student whose background is deficient in one or more areas may require subjects in these areas his first year. However, such subjects may not be taken for graduate credit toward the Ph.D. degree.

Examinations for Doctoral Students in Physics

Ph.D. Qualifying Examination — Prior to the second semester of his third year the student must have taken the Ph.D. Qualifying Examination. The examination itself consists of both a written and oral part, gi en, if the need demands, three times a year - in September, January, and June. The written examination consists of two four-hour examinations, given on successive days, testing the student's understanding of graduate-level material in the following subjects: Classical Mechanics, Classical Electricity and Magnetism (including Special Relativity), Quantum Mechanics (on the level of Schiff), Statistical Mechanics. Thermodynamics, Nuclear and Atomic Physics, and Mathematical Methods of Physics. The oral examination, given by the staff shortly thereafter, is directed by a committee selected from the faculty.

If the candidate fails on his first attempt, he must repeat the examination no later than September of his fourth year. If he fails a second time, he may no longer be considered a candidate.

Successful completion of the qualifying examination requires passing grades in both oral and written parts.

Final Examination — The candidate must pass a final oral examination administered by his thesis committee and other faculty members. This examination consists mainly of a defense of the results of his thesis but may also include background and other material at the discretion of the committee.

Requirements for Graduation — Requirements for the degree of Ph.D. in Physics are as follows:

1. **Residency** — A minimum of two years of full-time residency (18 credits per year). However, in the case of a candidate

who enters the Institute with a master's degree in Physics, the requirement is two years or one year subsequent to achieving a satisfactory score in the Ph.D. qualifying examination. In addition, no degree will be awarded to a candidate in less than three years if he enters with a bachelor's degree, or in less than two years if he enters with a master's degree.

2. **Grade Average** — A grade average of at least B- must be maintained in all graduate subjects offered for the degree. The lowest grade acceptable for doctoral credit is C-.

3. **Foreign Language** — The candidate must demonstrate to the satisfaction of the graduate faculty his reading proficiency in two of the following three languages: French, German, Russian.

4. **Examinations** — The candidate must pass the qualifying and final examinations.

5. **Thesis** — The candidate must conduct original research leading to a thesis, indicating his ability to carry out independent research on the doctoral level. This thesis must be unanimously approved by a thesis committee of at least three members of the faculty. The candidate's thesis adviser is a member of this committee.

6. **Tuition and Fees** — All tuition and fee requirements must be satisfied.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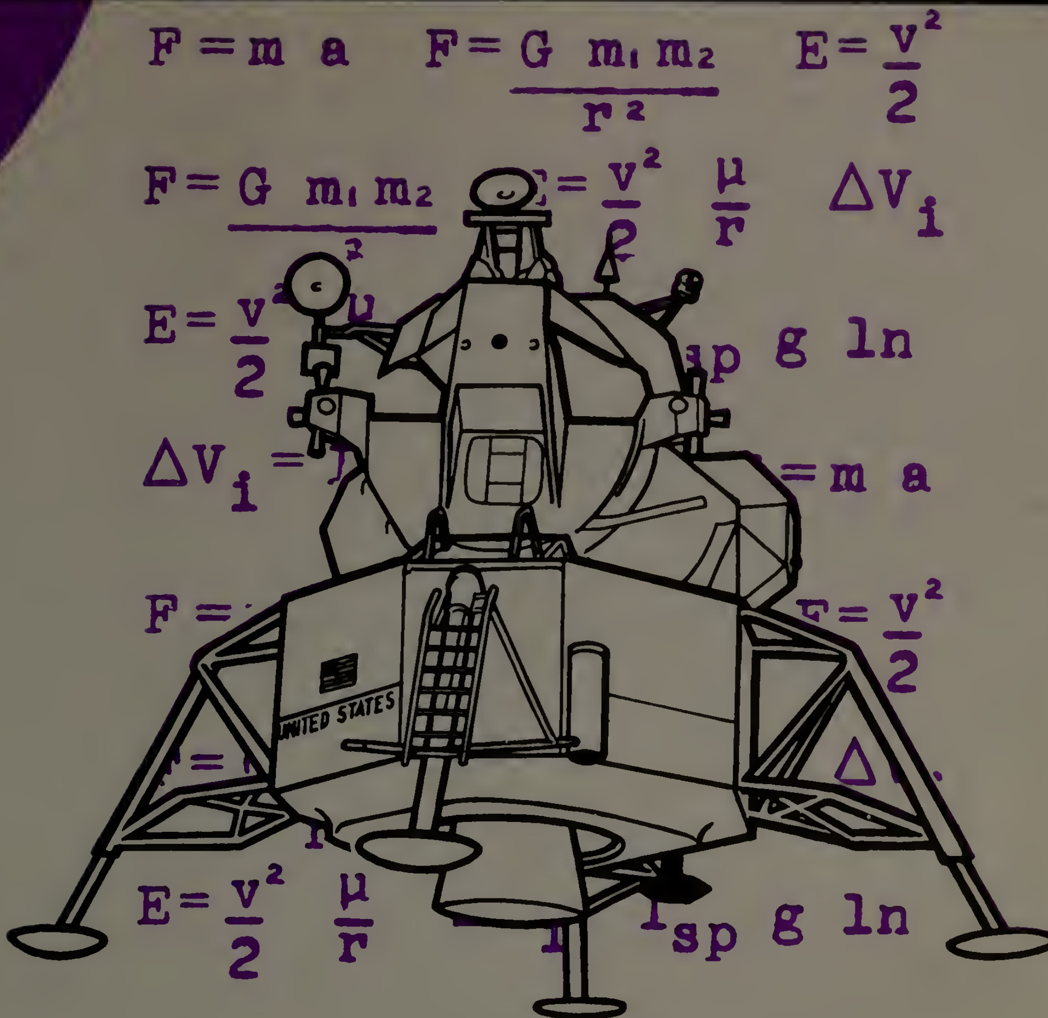

BULLETIN of THE LOWELL TECHNOLOGICAL INSTITUTE 1969 — 1970

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DIRECTORY

Further information concerning these subjects may be obtained by writing to the following sources:

Admissions	Director of Admissions
Scholarship aid	Dean of Students
Official transcripts	Registrar
Graduate studies	Director of Graduate School
Summer school	Director of Summer School
Evening study program . .	Director of the Evening Division
Alumni affairs	Alumni Office
Graduate placement . . .	Placement Director
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See supplement for late course changes and additions.

LOWELL TECHNOLOGICAL INSTITUTE

1969-1970 CATALOGUE

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LOWELL TECHNOLOGICAL INSTITUTE

Lowell, Massachusetts 01854

Established 1895

Operated by the Commonwealth of Massachusetts

Day programs leading to B.S., B.S. in B.A., M.S., and Ph.D. degrees

Evening programs leading to A.B.M., A.A.S., A.S., and A. Eng. degrees

Member of, or approved by, American Chemical Society, American Council on Education, College Entrance Examination Board, Engineers' Council for Professional Development, Massachusetts Department of Education, New England Association of Colleges and Secondary Schools

Total enrollment — 7105
Day Division — 2666
Evening Division — 2750
Summer School — 1425
Graduate School — 264

Men and women students from 20 states and 30 countries

Tuition: $200 for U.S. citizens who are residents of Massachusetts; $600 for all others

L.T.I. Research Foundation conducts research and development work for government and industry.

The main campus lies between Mass. Route 113 and the VFW Highway along the bank of the Merrimack River, one-half mile north of the center of Lowell, 25 miles north of Boston.

Office hours: 8:30 a.m. — 5:00 p.m., Monday through Friday

Telephone number: 454-7811 (Area Code 617)

* * *

The Board of Trustees reserves the right to waive, at its discretion, any of the rules and regulations stated herein, and to change any of the subjects or curricula, or portions thereof, without prior notice.

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ACADEMIC CALENDAR, 1969-1970

September 8, Monday	Freshman Orientation Week begins.
September 9, Tuesday	Registration of graduate students begins. Registration of transfer students.
September 10, Wednesday	Registration of seniors.
September 11, Thursday	Registration of juniors.
September 12, Friday	Registration of sophomores.
September 15, Monday	Classes begin.
September 22, Monday	Last day to register for new subjects or to drop a subject without academic penalty.
October 13, Monday	Institute closed. Columbus Day Observance.
November 11, Tuesday	Institute closed. Veterans Day.
November 25, Tuesday, 6 p.m.	Thanksgiving recess begins.
December 1, Monday	Classes resume.
December 19, Friday, 6 p.m.	Christmas recess begins.
January 5, Monday	Classes resume.
January 19, Monday	Examinations begin.
January 23, Friday	End of first semester.
February 2, Monday	Registration of seniors and graduate students.
February 3, Tuesday	Registration of juniors.
February 4, Wednesday	Registration of sophomores.
February 5, Thursday	Classes begin for sophomores, juniors, seniors and graduate students.
February 6, Friday	Registration of freshmen.
February 9, Monday	Classes begin for freshmen.
February 13, Friday	Last day for sophomores, juniors and seniors to register for new subjects or to drop a subject without academic penalty.
February 16, Monday	Institute closed. Washington's Birthday Observance.
February 17, Tuesday	Last day for freshmen to register for new subjects or to drop a subject without academic penalty.
March 20, Friday, 6 p.m.	Spring recess begins.
March 30, Monday	Classes resume.
April 20, Monday	Institute closed. Patriots Day Observance.
April 23, Thursday	Monday schedule of classes.
May 25, Monday	Institute closed. Memorial Day Observance.
May 26, Tuesday	Examinations begin.
May 30, Saturday	End of second semester.
June 7, Sunday	Commencement.

Normally, classes are held from 8 a.m. to 6 p.m., Monday through Friday.
This calendar is subject to change without notice.

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David A. Wagenknecht, B.A., M.A. (Boston University), Instr., Languages and Literature

Fahd G. Wakim, B.S. (American University of Beirut), M.A., Ph.D. (University of Texas), Lect., Physics

John W. Walkinshaw, B.S. (Lowell Technological Institute), Instr., Chemical Engineering and Paper Engineering

Francis R. Walsh, B.S., M.A., Ph.D. (Boston University), Asst. Prof., Social Sciences

Tso-Chou Wang, Dip. in Eng., D.Eng. (Technische Hochschule, Germany), Assoc. Prof., Mechanical and Textile Engineering

Joseph W. Waterman, B.S. (University of Vermont), M.B.A. (Boston University), Asst. Prof., Social Sciences

Arthur C. Watterson, Jr., B.S. (Geneva College), Ph.D. (Brown University), Asst. Prof., Chemistry

Harold L. Wedlick, B.S., M.S. (Wayne State University), Radiochemistry Supervisor in Nuclear Center, and Visiting Assoc. Prof., Radiological Sciences

Louis I. Weiner, B.S. (Temple University), M.S. (Lowell Technological Institute), Visiting Prof., Textile Technology

Robert J. Whelan, B.S. (Boston College), M.A. (Catholic University of America), Asst. Prof., Languages and Literature

Francis J. Wiedenmann, A.B., M.S. (Rutgers University), Health Physics Supervisor in Nuclear Center, and Visiting Asst. Prof., Radiological Sciences

Roger E. Wiehe, B.A. (Yale University), M.A. (University of Illinois), Ph.D. (Columbia University), Assoc. Prof., Languages and Literature

Martin Wilner, B.S. (Rensselaer Polytechnic Institute), M.S. (Yale University), Ph.D. (Massachusetts) Institute of Technology), Asst. Prof., Physics

Charles R. Wilson, B.S. (Lowell Technological Institute), Instr., Chemistry

Albert T. Woidzik, B.S. (Lowell Technological Institute), P.E. (Massachusetts), Prof., Textile Technology

Chuen Wong, Dip. of Science (Chung Chi College, Hong Kong), Ph.D. (Case Institute of Technology), Instr., Physics

Francis T. Worrell, B.S. (University of Michigan), M.S., Ph.D. (University of Pittsburgh), Prof., Prof., Physics

Waldo W. Yarnall, B.S. (University of Vermont), Director of Athletics

Louis E. Yelle, B.S. (Lowell Technological Institute), M.S. (Northeastern University), Asst. Prof., Economics and Management

Joseph A. Yeskewicz, B.S. (Springfield College), M.S. (University of Massachusetts), Resident Proctor, and Lect., Physical Education

Professors Emeriti

Horton Brown, B.S.

William G. Chace, Ph.B., M.S.

Harold C. Chapin, A.B., A.M., Ph.D.

Lester H. Cushing, A.B., Ed.M., Sc.D.

James G. Dow, A.B.

Charles A. Everett, B.T.C.

Elmer E. Fickett, B.S., Sc.D.

C. Leonard Glen

Martin J. Hoellrich

Nathaniel E. Jones

James H. Kennedy, Jr., B.T.E., M.S.

Gilbert R. Merrill, B.T.E.

John L. Merrill, B.T.E.

Charles R. Mingins, A.B., Ph.D.

John H. Skinkle, S.B., M.S.

A. Edwin Wells, B.T.E., M.Ed., P.E.

ADMINISTRATIVE ASSIGNMENTS

Chancellor's Office

Elizabeth P. Kennedy, CPS, Secretary
Helen G. Flack, B.S., Secretary

Executive Vice President's Office

Kleonike J. Bentas, Secretary

Provost's Office

Mary E. Perkins, Secretary

Administrative Services

James A. Sullivan, B.A., Ed.M., Administrative Assistant
Gerald F. Cronin, Contracts and Concessions
John E. Reynolds, Administrative Assistant
William L. Kelley, Housing
John L. Sayer, Supervisor of Payroll
Patricia J. Gallagher, Bookkeeper
Shirley D. Reed, B.S., Secretary
Eloise L. Brassard, Secretary

Admissions Office

Alice R. Redican, Clerk
Diane L. Goodrich, Secretary

Building and Power

George F. Abodeely, LLB, Administrator
Charles F. Johnson, Superintendent of Building and Grounds Maintenance
Charles DeFillipo, Plant Engineer

Business Office

Michael J. Chory, Accountant
George S. Zaharoolis, Accountant
Edna Nestor, Bookkeeper
Mary C. Sullivan, Bookkeeper
Irene D. Burns, Clerk
Anita V. Lacie, Clerk
Joan Cinq-Mars, B.S., Clerk
Helen Shanahan, Clerk
Gloria Willman, Clerk
Sharon Elie, Clerk

Data Processing

William J. Keenan, Jr., Director
Gilbert McGowan, Staff Assistant
Dolores Trudel, Statistical Machine Operator

Dean of Faculty's Office

Theresa D. Leblanc, Secretary

Dean of Student's Office

Barbara Jean Maccaron, Secretary
Gladys M. Coughlin, Secretary

Division of Chemistry and Applied Chemistry

Harriet E. Burns, Secretary
Mona M. Davis, Secretary
Frank B. Ridge, Chemical Storekeeper

Division of Evening Studies

Aristomenes G. Panos, B.S. in B.A., Recorder
Emma M. Millette, Secretary
Marguerite H. McGarry, Secretary
Kathryn Sheehy, Secretary

Division of General Studies

Joanne M. Poitras, Secretary
Lucille T. Eno, Secretary

Division of Physics and Engineering

Eleanor M. McKenna, Secretary
Jane Fagen, Secretary
Karen I. Volis, Secretary
Elaine DuBois, Secretary
Leo F. Patenaude, Electronic Equipment Supervisor

Graduate School Office

Carole L. Bean, Secretary

Guidance

Vittoria Rosatto, B.S., Counsellor

Health Services

Arlene D. Gordon, R.N., In Charge
Janet E. Connors, R.N.

In Service Training Program

John J. Delmore, Hon. Sc.D., Administrative Assistant
Doris A. Spinney, Secretary

Libraries

Vera Boyd Meehan, B.S., Assistant Librarian
Mary P. Frascarelli, Library Assistant
Eleanor T. Lessard, Library Assistant
Madeline M. Owens, Library Assistant
Ann V. Pendergast, Library Assistant
June E. Traverse, Library Assistant
Katharine F. Tarmey, Library Assistant
Johannah K. Ahearn, Library Assistant
Francis J. O'Brien, Library Assistant

Receptionist

Lorraine I. LeDoux

Registrar's Office

Nora M. MacBrayne, Secretary
Mary P. Kloppenburg, Clerk
Mabel M. Murphy, Clerk
Catherine P. Ouellette, Clerk

Summer School

Doris D. Couture, Secretary
Pauline S. Lessard, Secretary

GENERAL INFORMATION

History

Lowell Technological Institute was incorporated in 1895 and formally opened for the teaching of textile technology subjects on January 30, 1897. It was then known as the Lowell Textile School and awarded only certificates and diplomas. Growth of the school in size, prestige, and scope of curriculum was rapid, and in 1913 it was granted the right to confer four-year degrees in textile engineering and textile chemistry. In 1928 the name was changed to the Lowell Textile Institute to indicate more fully the collegiate status of the institution. Its continued growth resulted in further diversification of its areas of specialization, and since 1949 degree programs have been added in the fields of paper engineering, electrical engineering, plastics technology, mechanical engineering, chemistry, chemical engineering, physics, mathematics, nuclear science, nuclear engineering, industrial management, business administration, meteorology, and biological sciences. In view of the present greatly expanded scope of the engineering program, the name of the college was once more changed, in 1953, to Lowell Technological Institute. The Institute grants Bachelor of Science in Business Administration, Bachelor of Science, Master of Science, and Doctor of Philosophy degrees. Since 1918, when the property of the school was transferred to the Commonwealth of Massachusetts, it has been under the control and management of a Board of Trustees appointed by the Governor of the Commonwealth.

Accreditation

The Institute is a member of the Senior College Division of the New England Association of Colleges and Secondary Schools. The United States Department of Education and the Armed Forces consider such membership equivalent to regional accreditation. It also holds membership in the American Council on Education and in the College Entrance Examination Board. The Engineers' Council for Professional Development extends accreditation to the curricula in electrical, mechanical, and textile engineering, and the chemistry program is approved by the American Chemical Society.

Graduates of the Institute have been accepted for graduate study at nearly all leading universities. The Institute's prestige attracts students annually from many foreign countries. All races and religions are represented in the enrollment. Although the majority of its students are men, the Institute is co-educational.

Campus

The campus is situated 25 miles north of Boston, Massachusetts, in Lowell, a city of nearly 100,000, long famous as a textile center and more recently for its increasingly diversified industries. The 29-acre campus, situated on both sides of the Merrimack river, includes 13 main buildings, among them an auditorium-administration building, a library which is currently being greatly englarged, six classroom-laboratory buildings, four residence halls and a gymnasium. A $4,500,000 nuclear science center is under construction.

Alumni Memorial Library

The library, dedicated to Alumni of the Institute who served in World Wars 1 and 11 and the Korean conflict, has recently undergone an extensive expansion. The original building, constructed in 1951 by the Alumni Association, now houses the library's rare books, government depository collection, technical reports and a ground floor student activities area. The new addition, which is linked to the original building by means of ramps, houses most of the library functions. The main floor contains the lobby with its control desk, exhibition area, catalog, reserve book room, reference room as well as the administrative and work areas for the library staff. Two elevators serve the library building. The third floor houses the extensive periodical collections, including current issues as well as a microprint area. A section of this floor holds the abstracts and indices that serve as a guide to the periodical collections. The fourth floor houses the science and technology book collection while the fifth floor houses the collection of the humanities and the social sciences. On each floor shelving areas are mixed in with reading and lounge areas to give maximum accessibility to our collections. The lounge areas on the upper floors provide excellent views of the City of Lowell and the surrounding areas. The ground floor has a complete audio-visual area consisting of a master control room, a student listening room with thirty-one individual stations, six individual listening areas with equipment, an audio-visual office, a multi-purpose room seating 140 and a nine room radio station complex. The building seats approximately 1000 students and has a stack capacity of 450,000 volumes. A walkway under the side of the building adjacent to Smith Hall leads to the first aid station and the dormitory areas located behind the library.

Equipment

Laboratory equipment used in the instructional and research programs of the Institute is valued at more than $12,000,000. It includes such varied apparatus as an electron microscope, an-

alog and digital computers, and full-sized industrial machines as well as complete pilot-plant facilities in all technological areas, paper, plastics, leather, and textiles.

ADMISSION OF UNDERGRADUATES

New students are selected from those applicants who during their preparatory education have shown academic promise and strength of character. Besides scholastic rating and test results, high value is placed upon their evidence of leadership and contribution to school and community life.

Application for admission should be made as soon as possible after the first marking period in the candidate's senior year of secondary school. Applicants who apply before the first marking period will not be considered until the Admissions Office has received senior grades for this period. The responsibility of having these marks forwarded to Lowell Technological Institute rests with the applicant. Students from other countries are advised to start the application procedure not less than 12 months in advance of the expected date of enrollment.

The institute does not accept part time or special students, nor does it accept students at mid-year.

Correspondence is welcomed prior to their senior year from students in high school who may require help in adapting their secondary-school programs to fit the needs of the freshman year at the Institute. Requests for application blanks and all correspondence relating to matriculation should be addressed to the Dean of Admissions, Lowell Technological Institute, Lowell, Mass. 01854

Applications for admission must be received by the Institute on or before June 1, prior to the September in which the applicant wishes to matriculate.

All admission records, once submitted, become the property of the Institute and cannot be returned.

An applicant who is requesting financial assistance must file a Parents' Confidential Statement with the Institute.

Application Procedure

A candidate for admission should:

1. Complete the first two pages of the admission application form.
2. Attach a certified check or money order in payment of the application fee of $10 which is not refundable.
3. Submit the entire application form to the office of the secondary-school principal, with a request that the office fill out pages 3 and 4 and mail the completed application directly to the Dean of Admissions.
4. Request transcripts be sent to Lowell Technological Institute from any college, preparatory school, or institution of learning beyond secondary school attended.

5. Make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N.J., with a request to take the Scholastic Aptitude Test which is required of ALL applicants for admission to the freshman class at the Institute. The applicant must take the Scholastic Aptitude Test during the senior year in secondary school or thereafter. Letters, telephone calls, etc., will not be accepted in place of the official score card.

Applicants for admission who are in the upper 20% of their high-school class scholastically may be admitted by the Dean of Admissions prior to completion of the CEEB examinations. This examination, however, must be completed during the senior year and the results forwarded to Lowell Technological Institute before final acceptance is granted.

6. Undergo a complete health examination by a family physician. The physician must return to the Student Health Services on a form provided by the Institute, a certificate of good health, indicating the date of the examination. Health certificates are not sent to the applicant until he has been finally accepted by the Institute.

7. File a certificate of residence, filled in both by the candidate for admission and the city or town clerk of the place of residence. This certificate of residence is not sent to the applicant until he has been finally accepted by the Institute or accepted in the summer precollege program.

8. Upon receipt of a letter of admission, submit a prepayment of tuition (one-half of the first semester's tuition) within 30 days. This fee is nonrefundable if the applicant does not enroll. Students in the Precollege Refresher Program of the LTI Summer Session are not required to make prepayment of tuition.

If an applicant plans to attend the Institute, after receiving a final acceptance letter he should instruct the secondary school to send a transcript of final grades to the Admissions Office after graduation. The responsibility for sending this final transcript to the Admissions Office rests with the student. Failure to instruct his secondary school to forward this final transcript could result in his being not accepted in the fall.

Individual interviews are not required. However, applicants (and parents, when possible) may visit LTI on one of the regularly scheduled High-School-on-Campus days. Personnel from the Admissions Office will be available to answer questions, and guided tours of the campus will be conducted on these days. They will be held on April 28, 1969, October 24, 1969, January 9, 1970, February 27, 1970, April 15, 1970 and October 23, 1970 commencing at 10:30 a.m. in Cumnock Hall. No appointment is necessary.

Requirements for Admission

All applications are reviewed by the Committee on Admissions in order to determine the eligibility of each candidate, and the final decision as to eligibility is made by that Committee. Conditions for acceptance follow:

1. A candidate for admission must be a graduate of a secondary school approved by the New England Association of Colleges and Secondary Schools, Inc., the Regents of the State of New York, or a board of equal standing. The New England Association of Colleges and Secondary Schools accredits schools and colleges in the six New England states. Membership in one of the six regional accrediting associations in the United States indicates that the school or college has been carefully evaluated and found to meet standards agreed upon by qualified educators. Colleges support the efforts of public school and community officials to have their secondary school meet the standards of membership.

2. For all courses except Business Administration a candidate must have completed the following units of secondary-school study:

algebra (quadratics and beyond)	2 units
plane geometry	1 unit
trigonometry	½ unit
English	4 units
American history	1 unit
chemistry (including laboratory)	1 unit
or	
physics (including laboratory)	1 unit

Preference is given to applicants offering both chemistry and physics. Those who do not offer both are urged to make up the deficiency in the Summer Session Precollege Refresher Program. Besides the listed prerequisites, applicants may offer credit in such elective subjects as languages, history, mechanical drawing, social studies, and other sciences.

Combined prerequisites and electives should total at least 16 units. Each of these units is equal to one secondary-school subject satisfactorily completed during one academic year of at least 36 weeks of four 40-minute meetings each week, or the equivalent.

3. For admission to the course in Business Administration a candidate must have completed 16 units of approved high school work:

English	4 units
mathematics	2 units
American history and social studies	2 units
laboratory science	1 unit
electives	7 units

as well as the Scholastic Aptitude Test. Candidates should also indicate the choice of this program in the space provided on page one of the application.

Advanced Placement

Lowell Technological Institute subscribes to the program of the College Entrance Examination Board providing academic credit for students qualify for advanced standing. Those interested must take CEEB Advanced Placement Tests and have them submitted to Lowell Technological Institute for evaluation.

Students from Other Countries

All foreign applicants for whom English is a second language and who have been in the United States for less than two years must take an English Proficiency Test and have the results sent to the Dean of Admissions prior to filing a formal application with the Institute. The test used by the Institute to determine English proficiency is TOEFL (Test of English as a Foreign Language). Students should arrange to take this examination by writing to the Educational Testing Service in Princeton, New Jersey, 08540, U.S.A. and, as stated above, request the results be sent to Lowell Technological Institute.

The Institute accepts every year foreign applicants in numbers up to 5% of each entering class. In all other respects, the admission procedure for foreign students is the same as that required of U.S. citizens. They are urged, however, to have the transcript of their secondary-school and/or college records, as well as all other application materials, submitted, in ENGLISH, and not less than twelve months in advance of the expected date of enrollment. All applicants should have considerable facility in speaking and writing English and should have financial resources sufficient for at least their first year of study. They are expected to complete the same schedule of courses assigned to U.S. students.

To facilitate their adjustment to campus life, all freshman male students from other countries are required to live in the Institute's residence halls and are assigned to rooms shared by U.S. students. Students must supply their own towels, sheets, pillows and pillowcases, and blankets or may subscribe to a laundry service. Bedding, as well as clothing, should be suitable for a climate in which temperatures normally fall well below the freezing point during the winter months.

Transfer Credit Requirements

1. The formal application for all potential transfer credit students to Lowell Technological Institute must be filled out in its entirety. An affirmative answer to Question 6B is a requisite.

2. Completed application forms are considered by the Committee on Admissions. Selection of potential transfer credit students is based entirely on its determination. Successful candidates will receive Form No. 1 application following this decision. Students denied transfer credit will be notified by mail.

3. The prospective student, in completing this form, MUST indicate the curriculum major he intends to pursue at Lowell Technological Institute. Lowell Tech reserves the right to limit assignment of transfer students to specific curricula.

4. The transfer credit applicant should list in Column I our course title, and number all Lowell Tech subjects offered comparable to those *completed* at another college or university. This enumeration should also include such comparable subject titles as are *in progress* or *in contemplation*.

5. Those subjects taken at other institutions of learning should be listed by course title and number in Column II and matched to each one being petitioned for credit appraisal at LTI. Subjects in progress or contemplated for completion must likewise be included.

6. Credit will not be considered in subjects where the applicant's grade is lower than "C", or from an institution granting neither an associate nor bachelor's degree.

7. The third column should include catalogue page number and description of subjects taken at other recognized institutions. The fourth should include text required in the particular subject. The fifth must show the name of the institution where the applicant studied. *Do not mark Column Six.*

8. All completed information with the most recent transcript (s) and catalogues must be received at Lowell Technological Institute Admissions Office no later than April 1. *There will be no exceptions.*

9. As courses so indicated in Form No. 1 are completed, it is the obligation and sole responsibility of the individual applicant to supply his official transcript record to LTI. Transcripts for subjects ending after the April 1st deadline, must be received by August 1st. The College will not solicit this required information.

10. Students completing the equivalent of one full year of college work, waive the SAT examination requirement. Others must forward official copies of SAT figures from Princeton, New Jersey.

11. One full year of physical education completed at another institution will be considered for transfer credit. This subject is a degree requirement at LTI.

12. Applicants are advised that it is a rule of Lowell Technological Institute that NO CREDITS will be allowed a student after

he registers. It is therefore, imperative you list all credits you are hopeful of attaining before registration. After registration, a final decision concerning transfer credit rests with the Department Head in which the student is going to matriculate and the Dean of Admissions.

Re-Admission Policies

Due to the rapidly increasing number of applicants for admission, the problem of considering the application for re-admission of a student who has been dropped or withdrawn for scholastic deficiency has become more dificult.

It is clearly evident that the student who has already been given his chance does not have as much right to consideration as the student who is applying for the first time and who may be denied admission by limitation of numbers.

Therefore, it is the policy of the Admissions Committee that students leaving for scholastic reasons be required to fulfill the following conditions before their petition will be considered:

1. Students must remain dropped for at least one regular semester.

2. All students desiring consideration for readmission to Lowell Technological Institute must submit pages 1 & 2 of our application, completed in its entirety, with a check in the amount of $10.00. A letter giving the original date of entrance to this college and a brief resume of what you have done since you left Lowell Technological Institute *must* accompany this application. You should list in this resume other schools attended, subjects taken, and grades received.

3. They must show evidence of improved scholastic ability by enrolling in the day courses of some accredited institution and submit good grades in the subject in which whey showed weakness. These grades are not transferable but simply proof of worthiness for readmission. Students must apply for readmission for the entire year if they were freshmen. Only those courses in which B or better grades have been earned will be omitted. ROTC and Gym can be considered separately. Upperclassmen may be admitted to repeat the last semester of their failing year or be called upon to repeat the entire year as the situation warrants.

4. When all of these items have been received in the Admissions Office, a letter will be sent notifying you of the decision of the Committee on Admissions. No notification will be given by telephone or in person. Applications received after June 1 *will not be considered under any conditions* for admission to the Institute in September of that year. Only in very rare cases are students considered for readmission in February. If, however, in

the opinion of the Dean of Admissions, a student can be phased into his program of study with benefit to the student, application and credentials must be received prior to January 1 for consideration for the second semester admission.

5. Final decision will be made by the Dean of Admissions as to whether or not readmission would serve the best interests of the student and the Institute. Approval of readmission is not automatic and all decisions will be final.

GED Certificate

In order to encourage and support non high school graduates in their effort to obtain a college education, Lowell Technological Institute recognizes the GED TEST as an instrument to obtain the Massachusetts High School Equivalency Certificate which we in turn honor in lieu of a high school diploma. This applies to applicants from the state of Massachusetts only, and students applying from other states should consult their Department of Education regarding how the GED Certificate is used as an equivalent to a high school diploma.

STUDENT HOUSING AND SERVICES

Residence Halls

All non-commuting male students are required to live in the residence halls on campus insofar as our facilities permit unless excused in writing by the Dean of Students. Excuses are reviewed periodically and may be cancelled should conditions warrant.

Application for permission to occupy other living quarters must be made by letter to the Office of the Dean of Students. When permission is granted to live off campus, the students must record, in the Dean of Students office, their off-campus local address. Further, the students are obliged to notify the Dean of Students office of any subsequent change during the academic year.

Permission to reside at home is accorded in cases where the student lives within a normal commuting distance from the Institute or where financial hardship would be involved through living in a residence hall.

Dormitory rooms are furnished by the Institute and students are responsible for their care. Each student must supply his own sheets, pillow, pillowcases, blankets, towels and personal linens or may subscribe to the laundry service provided for all resident students at a reasonable cost. Each occupant of a room is responsible for damage to furniture, equipment and interior surfaces. In the event of damage to public areas (corridors, lobbies, shower rooms, etc.) the cost will be apportioned among all residents of the building concerned.

No facilities are available for the housing of female students. Those who do not live at home must make arrangements to reside off-campus. A list of off-campus rooms and apartments is supplied by the Housing Office. In the event that rooms for female students should become available on a limited basis, they will be assigned in the order in which applications are received.

Room assignments in residence halls are made for the full academic year. A change of room is not permitted except in rare instances and may be accomplished only after formal application is approved by the Housing Office.

The Institute reserves the right to reassign or transfer resident students within our dormitory buildings. In the event of such a reassignment or transfer of a student already in residence, the Institute shall not be liable for a refund to the former occupant of the room to which said reassignment or transfer is made.

Rental charge for each residence room is made for the full academic year payable upon registration prior to the Fall semester.


LEITCH HALL

Refunds for rooms will be made to students leaving the dormitories only after all rooms have been assigned and then in the order in which withdrawals take place.

While the room charge covers occupancy only during periods when the Institute is in regular session it may, at the discretion of the Dean of Students, be extended to include vacation periods under extenuating circumstances.

The Institute reserves the right to utilize student rooms during vacation periods for conferences and other groups or for housing of remaining students in one residence hall for safety reasons.

Residence Hall Regulations

1. The Resident Proctor is available to students by appointment except in the case of emergency. Appointments can be made through the head student proctor. (This regulation may be adjusted depending upon the dormitory).

2. The hours of the First Aid Dispensary, located behind the Library, are from 8:00 a.m. to 5:00 p.m. Report any illness or injury occurring at any other time to a member of the proctor staff.

3. Pets, intoxicating beverages, gambling, weapons of any sort, and narcotics are prohibited on campus.

4. Freshman resident students are not permitted automobiles.

5. Women guests of dormitory residents may be permitted in the lobby reception areas and parents and relatives may visit the rooms with permission of the Resident Proctor or Head Student Proctor, under individual dormitory conditions.

6. Concerning room conditions:

   a. Students are responsible for the condition of their rooms, its furniture, and equipment. No items of furniture or equipment are to be moved from the rooms.

   b. Students will be assessed for damage or theft of Insitute items.

   c. For health reasons, beds should be made daily and rooms must be kept clean.

   d. Electrical appliances such as radios, phonographs, clocks, electrical shavers, tape recorders, etc., are permitted. *Cooking appliances* of any kind are prohibited, as well as bicycles, auto parts, and motorcycles, from the residence halls.

   e. Pictures may be taped to cement walls and wood paneling only; never to plastered walls.

f. Food and juice are permitted in the residence halls, subject to the following three conditions:

1. Food that must be heated before it is consumed is not permitted.

2. Foodstuffs which have objectionable odors, i.e., some cheese and meat items are not permitted.

3. All foods without proper preservatives must be kept in closed containers and consumed within 24 hours. All wrappings, remains of and utensils used for their consumption must be cleaned and/or disposed of immediately.

g. Rooms should be locked when left vacant.

h. Screen must be kept intact on windows and ledges kept clear — nothing may be hung from the windows.

i. Rooms may be inspected by Institute officials or the proctor staff at any time.

j. Students must sweep floors, dispose of all trash, unplug all electrical appliances, and turn off all lights when leaving the residence halls for vacation periods.

k. Light bulbs may be obtained from the floor proctors or building custodians.

1. Signs are not permitted on the outside of the doors.

7. General Dormitory conditions:

a. Students are reminded that they live under group conditions and that acts of thoughtlessness and irresponsibility jeopardize the opportunities of everyone to study and work in the residence halls. When in doubt, be considerate of the other person.

b. Rooms are contracted for the entire academic year, and students are responsible for their room rent regardless of whether they occupy their rooms. No resident student is permitted at any time to maintain housing other than his residence hall assignment. Freshmen are assigned rooms by the Housing Office. Upperclassmen may sign up for the rooms they wish at the Housing Office or designated area. Room changes are permitted only during announced times near the beginning of each semester.

c. Incinerators are located on each floor for disposal of combustible trash. Bottles, cans, and noncombustible refuse is to be placed in the large barrels provided in each incinerator room.

d. Keys are provided for each room. Replacement fee in case of loss is $2.00.

e. In case of emergency, turn on room lights, close win-

dows and leave room with door closed and unlocked, then walk to the nearest building exit.

f. Lost and Found is located in the Office of Security Police, located in the Basement of Cumnock Hall. Deposit any lost items there.

8. Concerning discipline:

Members of the proctor staff will assist students in their orientation to residence hall life, and furnish more details on discipline policies and procedures. Appropriate discipline, in the form of room restriction or other measures, may be taken by the proctor staff toward students who refuse to act in a responsible, mature manner while in the residence halls.

Dining Halls

All students living in the residence halls are required to purchase a dining hall meal ticket. The Leitch Hall dining room is for the use of Bourgeois and Leitch Hall residents. Residents of Smith Hall, Eames Hall, and the Annexes will obtain their meals in the Smith Hall dining room. The contract food service provides two meals a day (breakfast and dinner), seven days a week, at a cost of $185.00 per semester. This charge is payable upon registration prior to each semester. The Smith Hall dining room is open at noon to provide food service on a cash basis for all students. The Eames Hall Snack bar is open intermittently during the day and evening.

Health Service

The dispensary is in the charge of two registered nurses for eight hours each school day. Students receive first-aid treatment at the dispensary and are advised as to the best procedure to take in case of illness. Medical services are available to students 24 hours daily. There are three excellent modern hospitals in the immediate vicinity of the Institute. Students must bear their own medical fees and hospital charges.

If a student requires emergency surgical treatment, every effort is made to communicate with a parent or guardian. Failing this, such action is taken as appears to be necessary in the interest of the student.

Accident insurance during the academic year is compulsory and is included in the activity and insurance fund. Health insurance also is available, on a voluntary basis, through the Office of the Dean of Students.

Counselling

The counselling program, under the supervision of the Dean of Students Office, starts with the admissions procedure and continues throughout the freshman year. During Orientation Week, the freshman attends a series of lectures the purpose of which is to help in the adjustment to college requirements.

Freshmen should contact instructors for academic problems and, if necessary, a referral may be made to the Director of Student Counselling for further assistance. Personal difficulties such as financial or similar problems should be brought directly to the Director of Student Counselling.

Due to the large numbers of students each year, it is impossible to call in all students. Responsibility for interviews must rest with the student who needs advice or clarification.

Other phases of the counselling program include lectures on effective study and tutoring programs under the sponsorship of Circle K, as well as faculty tutorial sessions. In the second semester of the freshman year a series of lectures is offered to help the student become aware of the curricula at the Institute and determine what course he should elect for the next three years.

Counselling in the upper classes is generally conducted in scholastic matters by the Head of the department concerned and in personal problems by the Dean of Students office.

STUDENT EXPENSES

The various expenses described in this section apply only to students enrolled in the day program at the Institute. Fees and expenses of the Evening Division are listed in a separate bulletin. All fees are established by the Board of Trustees and are subject to change without notice.

Payment of tuition and fees is an integral part of the registration process which must be completed before a student may attend classes. In special cases a delay in payment may be authorized, but all fees must be paid no later than the close of the sixth week of classes of the semester concerned. Requests for such a delay must be approved by the Dean of Students before a student's registration is complete.

APPLICATION FEE $10

1. The Institute requires the prepayment of 50% of the first semester's tuition within 30 days of the date upon which the applicant is accepted for admission. For Massachusetts residents this amounts to $50. This prepayment is forfeited if the student fails to register at the Institute. In rare instances, such as sickness which would prevent the applicant from enrolling, this rule may be waived by the Dean of Students.
2. The application fee is NOT credited to the student's tuition.

TUITION **(per year)**

U. S. citizens who are residents of Massachusetts. . . . **$200**

All others. **$600**

Special students carrying a total of 10 or more credit hours must pay the full tuition fee.

Special students carrying less than 10 credit hours pay charges according to the following schedule:

U. S. citizens who are residents of Mass. . **$10.00 per cr. hr.**

All others. . . . . **$30.00 per cr. hr.**

Because Lowell Technological Institute is state-supported, its educational program and facilities are made available at a low tuition rate to students from the Commonwealth. Eligibility for the low tuition is determined under the following policies established by the Board of Trustees:

1. Every student claiming residence in Massachusetts must file with the Dean of Students a certificate signed by either the town or city clerk of the community claimed as legal residence, stating that his parents or guardian is a legal resident of the Commonwealth of Massachusetts.
2. The residence of a minor follows that of the parents,

unless the minor has been emancipated. A minor student who has been emancipated must also present documentary evidence of emancipation.

3. A minor under guardianship must present documentary evidence of the appointment of a guardian in addition to the certificate of residence of a guardian.
4. The residence shown on the application at the time of initial application for admission determines the appropriate tuition charge to be made for the entire period or periods of the applicant's enrollment.
5. The residence of a wife follows that of the husband.
6. Application for classification of residence must be made by the student on a prescribed form obtainable at the Institute. Misrepresentation of facts to evade payment of the proper rate of tuition constitutes sufficient cause for suspension or permanent separation from the Institute.
7. Payment of one-half of the total yearly tuition must be made during the registration period of each semester.
8. The President of the Institute is authorized to adjust individual cases within the spirit of these rules.

ROTC DEPOSIT $25

This deposit covers loss of, or damage to, uniforms or equipment used for ROTC instruction and is required of all students enrolled in that program. The entire amount, minus charges, is refunded upon completion of ROTC requirements. If, at any time, the charges against a student exceed the amount on deposit, he must pay the charges and make an additional deposit of $25.

ACTIVITY AND INSURANCE FUND $49

Each student enrolled in 10 or more total credit hours must pay this sum in the first semester for the entire academic year. Payment of this entitles the student to free admission to all athletic events, a mailbox in the campus post office, subscription to the student newspaper, and a copy of the yearbook. A portion of the fund helps to support the general student activities under the jurisdiction of the Student Council and other general and special activities at the direction of and under the jurisdiction of the President. It pays for the compulsory accident insurance policy which covers each student during the academic year. It is not refundable.

RESIDENCE HALLS

The residence hall charge is $350 per student per year. Each student will be billed for the room for the entire academic year. In the event a student is dropped at any time during the year he is still responsible for the room charge and will be reimbursed only if the room is rented to another student.

LATE REGISTRATION FEE $25

A student who does not complete his registration (including the payment of all fees) by the close of the registration period must pay this additional fee.

AUDITING FEE .... $5/credit hour

All students regularly enrolled and paying the full tuition charge in any semester may audit courses in that semester without charge, provided permission is obtained by special action through the Office of the Dean of Students.

Students not regularly enrolled or not paying the full tuition charge for the semester must pay $5 per credit hour to audit a course and must obtain permission from the Dean of Students.

COMMENCEMENT FEE $15

This fee applies to graduating students only and covers such Commencement expenses as degree form and case, rental of cap and gown, invitations, printing, and any other expenses approved or directed by the President.

FRESHMAN DUES $5

All students classified as freshmen must pay this fee when they are billed.

OFFICIAL TRANSCRIPT FEE $1/copy

Each student is allowed free of charge a total of three transcripts of his scholastic record. A charge of $1 per copy is made for each additional transcript.

BOOKS AND MATERIALS

Students must provide their own books, stationery, drafting equipment, and the like and must pay for any breakage or damage they may cause to machines, laboratory equipment, or other property of the Institute.

Laboratory equipment may not be removed from the premises except by special permission.

TUITION REFUND SCHEDULE

Application for refunds must be filed with the Bursar upon the student's withdrawal, and the refunds will be made as follows:

No. of Weeks At least	But less than	Refund Rate
0	2	80%
2	3	60%
3	4	40%
4	5	20%
5 and over		None

SUMMARY OF EXPENSES PER YEAR

Tuition

U. S. citizens who are residents of Massachusetts **$200**

All others **$600**

Residence halls .... **$350 per student per year**

Student activity and insurance fee .... **$ 49**

ROTC deposit .... **$ 25**

Books, supplies, and related miscellaneous

expenses (approximate) **$100**

The Boarding fee is $370 per student, per year.

STUDENT REGULATIONS

Conduct

Students admitted to the Institute are presumed to be ladies and gentlemen and of sufficient maturity and poise to enable them to live in an adult environment. Regulations are framed not to restrict the conduct of individuals or groups but to provide a pattern so that a large body of students may live and work in harmony.

A STUDENT MAY BE DROPPED FROM THE ROLLS WHENEVER IT IS CONSIDERED IN THE BEST INTERESTS OF THE INSTITUTE.

In some laboratories students are required by state law to wear safety eyeglasses, which may be purchased at the LTI Bookstore. The instructor in each class requiring the use of such eyeglasses will inform the students of the necessity of using them.

Attendance

An excused absence system is applicable. For regulations consult the KEY (Student Handbook).

Academic Grades

The student's semester rating is a weighted value used to denote his relative standing. The values assigned are as follows:

A+	4.30	(97-100)	C+	2.30	(77-79)
A	4.00	(93-96)	C	2.00	(73-76)
A−	3.70	(90-92)	C−	1.70	(70-72)
B+	3.30	(87-89)	D+	1.30	(67-69)
B	3.00	(83-86)	D	1.00	(63-66)
B−	2.70	(80-82)	D−	0.70	(60-62)

F 0 (below 60)

These point values, when multiplied by the credit hours assigned to the subject and added together, are divided by the sum of the credit hours to give the student's semester rating. The cumulative rating for more than one semester is obtained in the same manner as the computation for the rating of a single semester.

Dean's List

The Dean's List is composed of students who have a semester rating of 3.00 or higher, with no current failures.

PROBATION AND DISMISSAL — ACADEMIC

Probation

A student is automatically placed on probation under the following conditions:

A. When the student's semester rating is less than 1.35

B. When the cumulative rating of a student not on probation is less than the appropriate value

Freshman Year-end	1.40
Sophomore Mid-year	1.45
Sophomore Year-end	1.50
Junior Mid-year	1.55
Junior Year-end	1.60
Senior Mid-year	1.65

The probationary period covers the entire regular semester following the issuance of the semester or cumulative rating which placed the student on probation.

A student on probation may not represent the institute in any public function or extracurricular activity and may not hold class or other offices during the term of probation, and is allowed no unexcused absences from classes.

Dismissal

A student is automatically dropped from the Institute for at least one semester under the following conditions:

A. When the student's semester rating is below 0.70

B. When the student's semester rating is less than 1.35 for two consecutive semesters

C. When the student, while on academic probation, fails to achieve the cumulative rating required in 1-B above

Upon request of a student who has been notified of impending academic dismissal from the Institute by the above conditions, the Dean of Students, in the case of a freshman, and the appropriate Department Head, in the case of an upperclassman, will grant the student a hearing to review that student's case to ascertain if extenuating circumstances exist which would justify further consideration.

A student dropped from the Institute must take subjects at some other college before applying for readmission to LTI.

PROBATION AND DISMISSAL — DISCIPLINARY

A student is placed on disciplinary probation by the Dean of Students when in his opinion a student has violated a basic rule of conduct or an established rule of the Institute. The probationary period covers the entire semester in which the violation took place. The length of time of the censure can be a longer period of time.

A student who violates the basic tenent of disciplinary probation may be dismissed from the Institute.

If the original violation is of a serious nature, the Dean of Students may dismiss the student without benefit of a probationary period.

Any student on disciplinary probation may not represent the Institute in any public function or any other extra-curricular activity and may not hold any class office or other office during his term of probation, nor is he allowed to cut any classes or laboratory sessions.

Requirements for Graduation

In order to be recommended for the baccalaureate, a student must:

1. Complete successfully one of the prescribed curricula with no substitutions for major subjects and no unremoved failures in major subject.
2. Earn a cumulative rating of 1.70 or above for the entire period at the Institute.
3. Fulfill the residence requirement of one academic year.

Graduation Honors

Academic honors are awarded at the annual Commencement exercises by appropriate notation on the degree forms for the baccalaureate and by printing in the Commencement program the names of the students who have earned such recognition. Honors are awarded according to the following standards of achievement:

With Honors — graduation with a rating of at least 3.00 but less than 3.30 for the entire period of study at the Institute;

With High Honors — graduation with a rating of 3.30 or higher for the entire period of study at the Institute;

With Highest Honors — graduation as the highest ranking student in the class and with a rating of 3.70 or higher, contingent upon the completion of at least six semesters of work at the Institute.

FINANCIAL AID

At L.T.I. financial aid is available to full time students in good standing who are citizens of the United States, during the Fall and Spring and Summer Session. Aid to a student may be in the form of a National Defense Student Loan, a Federal Grant, part time employment in the Federal College Work-Study Program, a scholarship, or any combination of these financial aids to continue their education. Each program is designed to meet the particular need of the student and the applicant is required to complete the required forms regarding parental income and assets since this will be the basis for determining the amount and type of aid granted.

A Parents Confidential Statement must be sent to the Institute by all candidates, through the College Scholarship Service, Princeton, New Jersey.

Students may obtain applications and information regarding these programs at the Financial Aid Office, O 112.

SCHOLARSHIPS

Various trusts, organizations, civic bodies, and industrial firms have contributed funds for scholarships available to students and prospective students at the Institute. Many of the scholarships are renewable annually for the balance of the student's undergraduate program, provided a satisfactory scholastic average is maintained; others are for a specified period of time. At present, scholarships are available only to citizens of the United States.

All entering freshmen who are candidates for scholarships should make direct application for admission to the Director of Admissions before April 1 and should have completed the Scholastic Aptitude Test of the College Entrance Examination Board by that date. To arrange for the test, candidates must make direct application to the College Entrance Examination Board, P. O. Box 592, Princeton, N. J., with a request to take the Scholastic Aptitude Test. In addition, the applicant should request and complete a scholarship and/or loan application.

Unless otherwise specified, all scholarships are granted by vote of the Scholarship and Awards Committee of the Institute. While honor grades are not required to maintain a scholarship, the recipient is expected to remain in good standing in college and to progress normally from year to year. Grades which prevent normal progress or conduct which results in probation, suspension, or dismissal terminates the scholarship.

AVAILABLE TO FRESHMEN AND UPPERCLASSMEN

Albany Felt Company Scholarship

One annual grant of $500 to a freshman entering the Institute is

made by the Albany Felt Company. Each recipient is given an opportunity for summer employment at the company while in college.

Alumni Association Scholarships
The LTI Alumni Association makes available every year several scholarships covering tuition and miscellaneous fees. They are renewable if satisfactory scholastic standing is maintained. Funds for these scholarships are derived from the following sources:
Stephen E. Smith Scholastic Fund
James T. Smith Fund
Arthur A. Stewart Memorial Scholarship Fund
Warwick Chemical Foundation in memory of Walter Nowicki
New York Chapter, LTI Alumni Association

Berkshire Hathaway, Inc. Scholarships
A number of scholarships covering tuition and living expenses for four years are offered in Textile Engineering and Textile Technology by Berkshire Hathaway, Inc., Providence, R. I. Male employees and sons of employees only are eligible. Students interested should contact Berkshire Hathaway, Inc., 704 Hospital Trust Building, Providence, R. I.

Russell L. Brown Scholarship, donated by

Davis and Furber Machine Company
This scholarship is open to a student who plans to major in Textile Engineering or Textile Technology. Preference is given to employees and sons or grandsons of employees of Davis and Furber Machine Company. Selection is based on general scholarship, initiative, and need. The stipend is $300. Appointments are for one year only but are renewable.

Admiral Carl Espe Scholarship
This $200 scholarship is awarded to the male student presenting the best exhibit in Technorama, science fair for Merrimack Valley high schools, held each spring at the Institute.

Joseph Kaplan Memorial Scholarship
This $250 scholarship is awarded annually to the winner of Technorama, science fair for Merrimack Valley high schools.

City of Lowell Scholarships
The City of Lowell provides a total of five scholarships every two-year period through competitive examination to residents of Lowell, Mass., who are enrolled in the entering freshman class at the Institute. The amount of each scholarship is $200, and each is renewable provided satisfactory scholastic grades are maintained.

Lowell Sun Charities Scholarship Fund

Through this fund, established by Lowell Sun Charities, Inc., one or two Greater-Lowell residents are eligible for full tuition scholarships, renewable annually. Selection is based upon evidence of good moral character and high scholastic standing.

Commonwealth of Massachusetts Scholarships

Twenty scholarships of $250 each are available annually to residents of the Commonwealth of Massachusetts who are enrolled in the freshman class at the Institute. Awards are made on the basis of competitive examination, and financial need and the scholarships are renewable on the condition that satisfactory grades are maintained.

Paper Engineering Department Scholarships

Ten or more scholarships with annual stipends of $500 are available to upperclassmen and selected graduate students in Paper Engineering who fulfill the scholarship requirements of a minimum of 2.0 cumulative rating. These scholarships are normally maintained from year to year provided the student maintains his academic rating.

Present contributors to the Scholarship Fund include the following:

Byron Weston-Crane Company
Carter Rice Storrs & Bement, Inc.
Weyerhaeuser Company
Dennison Manufacturing Company
Erving Paper Mills
Fraser Paper, Ltd.
Hollingsworth & Vose
International Paper Company
Ludlow Corporation
Mohawk Paper Mills
Nashua Corporation
Oxford Paper Company
Tileston & Hollingsworth
S.D. Warren Div. Scott Paper Company

Sylvan I. Stroock Scholarship, donated by S. Stroock & Co., Inc.

A $500 scholarship is awarded each year on the basis of scholarship, financial need, leadership, and promise of success in textile fields from funds established by S. Stroock & Co., Inc.

Science Count-Down Scholarship

A one-year tuition scholarship is available annually to a student who has won first place in Science Count-down, the televised science quiz for Massachusetts eighth-grade pupils, co-sponsored by the Institute and WBZ-TV, the Westinghouse Broadcasting Company television station in Boston.

United Elastic Corporation Scholarships

Scholarships of $250 are available through the United Elastic Corporation to students in textiles. Preference is given to employees or their families, or to residents of communities where plants are located. Especially preferred are native New Englanders. Recipients must agree to work summers in approved plants, and the Corporation furnishes suitable employment to scholarship recipients during summer vacations and following graduation, as far as possible. Awards are based upon good character and standing in the community and aptitude for technical training. They are renewable annually under the usual conditions. Applications should be made through the plant nearest the residence of the applicant. Plants are located at Easthampton, Lowell, and Littleton, Mass., West Haven, Conn.; and Stuart, Va.

Jacob Ziskind Memorial Fund for Freshmen

This scholarship, open to freshmen only, was established by employees of the former Merrimack Manufacturing Company in memory of Jacob Ziskind. Qualifications include good character, scholastic record, initiative, and ability.

Outside Scholarship Assistance:

The Afro-American Society at L.T.I. has compiled a list of Private, Public, and Federal Scholarships, Funds, Fellowships, and Loan Programs that are available to disadvantaged persons.

The Financial Aid Office has copies of this list which will be sent upon request. Correspondence should be addressed to the Director of Financial Aid, Lowell Technological Institute, Lowell, Massachusetts 01854.

AVAILABLE TO UPPERCLASSMEN ONLY

AFROTC Financial Assistance Program

Financial Grants are provided on a competitive basis to a limited number of cadets entering Aerospace Studies 200 - 300 - 400 in the Air Force ROTC four year program. The grant covers full tuition costs, books, laboratory expenses and incidental fees. A grant earned as a sophomore or junior continues until graduation as long as the cadet maintains acceptable stand-

ards. Cadets also receive $50 per month subsistence allowance.

Allied Chemical Foundation Scholarships

Two grants of $750, given by the Allied Chemical Corporation, are awarded to worthy students majoring in Textile Chemistry or Textile Engineering.

A.S.T.M.E. Awards

Merrimack Valley Chapter 113, American Society of Tool and Manufacturing Engineers, awards $100 annually to a junior-class member in good standing of the Student Chapter on the basis of leadership, scholarship, need, and contribution to the Society. The A.S.T.M.E. Student Chapter presents the Prof. J. Arthur Ainsworth award of up to $100 annually to any chapter member in good standing on the same terms.

Boston Paper Trade Association Awards

Two awards, each for $150, are open to upperclassmen enrolled in the Paper Engineering Department and who are residents of New England. Awards are based on character, proven interest in the Paper Industry and academic performance

The Chemical Club of New England Scholarship

This scholarship in the amount of $400 is awarded to a student in Chemical Engineering or Chemistry who is a resident of New England. Selection if based on ability and financial aid.

Chemstrand Corporation Scholarship

A scholarship of $500 is available to a superior, deserving student enrolled in textiles. Donor is the Chemstrand Corporation.

DeBell-Richardson Scholarship

DeBell-Richardson, Inc., the D. & R. Pilot Plants, Inc., and John M. DeBell have established a scholarship for a student majoring in Plastics Technology. It is awarded on the basis of scholastic success, extracurricular activities, and financial need.

Dixie Cup Scholarship

The Dixie Cup Division of American Can Company of Easton Pa., has established a scholarship in the amount of $500 per year. Students majoring in Chemical Engineering, Electrical Engineering, Mechanical Engineering, Paper Engineering, or Plastics Technology are eligible to apply, and selection is based on scholastic achievement, financial need, and extracurricular participation. The Company provides summer employment for the student holding the scholarship.

Foster Grant Scholarship

The Foster Grant Company, Inc. of Leominster, Mass.,

makes available on a one-year basis a tuition scholarship to a deserving student in Plastics Technology who is a resident of Massachusetts. Preference is given to a sophomore living in the Leominster area; however, if there are no applicants from that area, another candidate may be chosen. Scholarship, personality, and over-all student contribution to extracurricular activities are the general criteria used in selecting the recipient.

Gehring Foundation Memorial Scholarships

Scholarships in the amount of $75 per semester, renewable under the usual conditions, are made possible through the Gehring Memorial Foundation of New York, which may review the applications recommended by the Scholarship Committee. The scholarships are in memory of Henry G. Gehring and his son, Edward H. Gehring, both of whom were engaged in the lace industry.

NOPCO Chemical Company Scholarship

The NOPCO Chemical Company of Newark, N. J., has established two $250 scholarships open to students majoring in Chemical Engineering, Chemistry, Paper Engineering, Plastics Technology, or Textile Chemistry who have proved themselves scholastically and who are active in extracurricular programs.

Society of Plastics Engineers Scholarship

A scholarship is granted annually by the Eastern New England Section of the Society of Plastics Engineers, Inc. to an upperclassman majoring in Plastics Technology.

Uniroyal Incorporated

This Foundation has established scholarships for students who have successfully completed at least two years of college in which they have demonstrated leadership, capacity for higher education, and a recognition of its cultural and economic value. Applicants must be in need of financial assistance, and recipients assume a moral obligation to repay over a reasonable period at least 25% of the scholarship aid received.

Western Electric Fund Scholarship

This scholarship, covering the cost of tuition, books, and fees for one year, not to exceed $800, is available to an under-graduate in an engineering program. Selection is based upon need and ability.

Jacob Ziskind Memorial Scholarship Fund

Through a fund established by the Trustees of the Jacob Ziskind Trust for Charitable Purposes, scholarships are awarded annually and are renewable under the usual conditions. The scholarships cover tuition and books. Seniors, juniors, and sophomores who have demonstrated high scholarship, financial need, and qualities of good character and lead-

ership are eligible. Preference is given to, but not restricted to, students who received grants as freshmen from the Jacob Ziskind Memorial Fund for Freshmen.

Russell Weeks Hook Scholarships

Six undergraduate scholarships for needy, qualified students in Chemistry or Textile Chemistry in the amounts of $225 are awarded each year, two awarded to each of the upperclasses.

AVAILABLE TO GRADUATE STUDENTS ONLY

Fellowships for graduate students are listed and described in the Graduate School section of this catalogue.

LOANS

Student Loan Fund

A loan fund is available to upperclassmen needing financial assistance to continue their education at the Institute. Students may apply for loans through the Faculty Treasurer of the Lowell Technological Associates, Inc.

Repayments which are made while the student is still enrolled at the Institute are interest-free. On loans repaid after the student leaves school interest is charged at the rate of 4%, starting three months after the date on which the student officially terminates enrollment. Repayments are not required until the student separates from the Institute, at which time repayments become due quarterly at the rate of $10 per quarter the first year and $20 per quarter each year thereafter until the loan is repaid. Additional payments may be made at any time to reduce indebtedness at a more rapid rate.

Geigy Loans

Geigy Dyestuffs, a division of Geigy Chemical Corporation, has established a loan fund restricted to students majoring in Chemistry, Textile Chemistry or Paper Engineering. The fund operates under the same conditions as the Student Loan Fund. Application for Geigy loans may be made to the Dean of Students.

FEDERAL FINANCIAL AID PROGRAMS

Available to Undergraduate & Graduate Students.

National Defense Student Loan

The National Defense Education Act offers loans to needy students. Repayment begins one year after graduation, unless

military service intervenes, whereupon repayment begins one year after leaving service. Interest is charged at the rate of 3%, beginning with the first payment. Repayments may be made over a 10-year period. A 50% forgiveness clause is included for students who enter the field of elementary- or secondary-school teaching for a period of five years.

College Work-Study Program

The Economic Opportunity Act of 1964 (P.L. 88-452) as amended by Economic Opportunity Act of 1965 (P.L. 89-253) and the Higher Education Act of 1965 (P.L. 89-329) Title I Part C established the College Work-Study Program to stimulate and promote the part time employment of students, particularly students from low income families who are in need of the earnings from such employment to pursue courses of study in institutions of higher education. At LTI the program is available to full time students in good standing at the undergraduate and graduate levels during the Fall and Spring semesters and during the Summer Session.

Educational Opportunity Grants

The Higher Education Act of 1965, Title IV, Part A (P.L. 89-329) affirms the policy of the United States to strengthen the educational resources of our colleges and universities and to provide financial assistance for students in post-secondary and higher education. The Act initiates a program of educational opportunity grants through institutions of higher education, to assist in making available the benefits of higher education to qualified high school graduates of exceptional financial need, who for lack of financial means of their own, or of their families, would be unable to obtain such benefits without such aid.

AWARDS

AVAILABLE TO UNDERGRADUATE STUDENTS ONLY

American Association of Textile Chemists and Colorists Book Prize. This is awarded to the outstanding graduating senior in the Textile Chemistry course and includes a junior membership for one year in the A.A.T.C.C. The recipient is recommended by the Division of Chemistry and Applied Chemistry. The academic standing of the candidate is an important factor in the decision.

American Association for Textile Technology Award. This is made to the member of the senior class majoring in a textile program who is rated highest in scholarship, technical ability, industry, judgment, leadership, reliability, and ability to work with others.

ACS Student Affiliate Chapter Award. A plaque is presented annually by the LTI Student Affiliate Chapter of the American Chemical Society to the outstanding senior majoring in Chemical Engineering or Chemistry, based upon academic performance and demonstration of research capability.

ASTME Award. The Merrimack Valley Chapter, American Society of Tool and Manufacturing Engineers awards $100 to a member of the Student Chapter of the ASTME who is high in scholastic standing and in need of financial assistance.

Chemistry Award. A book prize is awarded to the member of the freshman class who shows the greatest achievement in chemistry during the first semester.

Circle K Book Award. A book is awarded to the freshman with the highest cumulative average for the first semester of his first year at the Institute.

Dean's Key. This award, sponsored by the Student Council, is given to the senior who has made the greatest extracurricular contribution to the Institute during his four years at college.

Department of Physics and Mathematics Awards. Handbooks are presented annually by the Chemical Rubber Company to the outstanding freshman in the physics program and the outstanding freshman in the mathematics program.

Ben Faneuil Award. An annual award of $100 is made by Mr. Ben Faneuil of The Chelsea Industries, Chelsea, Massachusetts, to the sophomore majoring in Plastics Technology with the highest cumulative average.

Jacob K. Frederick Memorial Award. Omicron Pi Fraternity makes an annual award of $50 in memory of Professor Jacob K. Frederick to a freshman, based on scholastic achievement and extracurricular participation. The award is applicable to the recipient's tuition in the ensuing academic year.

Barnett D. Gordon Award. An award of $250 is presented to the freshman matriculating at the Institute who achieved the highest score in the mathematics section of the Scholastic Aptitude Test of the College Entrance Examination Board. It is given by Barnett D. Gordon, formerly of the Board of Trustees of the Institute.

Samuel P. Kaplan Memorial Fund Awards. An award of $100 is given at the end of each semester to the highest-ranking student in basic knitting. The fund was established by the New England Knitted Outerwear Manufacturers' Association in memory of Samuel P. Kaplan.

Helen U. Kiely Award. This award acknowledges by permanent inscription on a plaque the senior student in Paper Engineering selected by his classmates as having outstanding qualifications of merit. It is made by the New England Section of the Technical Association of the Pulp and Paper Industry in recognition of Helen U. Kiely's distinguished service to the industry.

The Northern Textile Association Award. A medal is presented to the member of the graduating class majoring in Textile Engineering or Textile Technology who has maintained the highest scholastic standing throughout the four years of his undergraduate work.

Louis A. Olney Book Prizes. Selected reference books are awarded to the outstanding freshman, sophomore, and junior students in Chemistry or Textile Chemistry who are recommended by the Division of Chemistry and Applied Chemistry on the basis of academic standing in Chemistry.

President's Medal. This award is made to the student who is graduated With Highest Honors for the most distinguished academic record in his class.

The Harry Riemer Honor Award. This award is made available through the Textile Veterans Association of New York in honor of Mr. Harry Riemer, one of the textile industry's foremost personalities in the trade publication field. The award, which consists of a $25 United States Savings Bond, is made to an outstanding textile graduate who has been active in extracurricular activities and who has maintained a high level of scholastic achievement.

Radio Station WLTI Award. The staff of the student-operated radio station WLTI awards a plaque annually to a member outstanding for conspicuous service and furtherance of the goals of the station.

Textile Veterans Association Honor Award. A bronze medallion

is given to an outstanding graduating student in a textile course on the basis of scholastic achievement, extracurricular participation, and over-all contribution to the Institute. Preference is given to veterans. The Association making the award represents all veterans of World War II now affiliated with the textile and allied industries.

The Wall Street Journal Student Achievement Award

This award recognizes the senior in Business Administration or Industrial Management who has achieved the best combination of academic and extracurricular excellence. The award consists of an engraved paperweight, a year's subscription to the Wall Street Journal, and a plate on the permanent plaque established for the award winners.

OTHER ASSISTANCE FOR MASSACHUSETTS
Residents only

Board of Educational Assistance Scholarships

These scholarships for one-quarter, one-half, or full tuition are available both to freshmen and to upper classmen. For full information write to:

Executive Secretary
Board of Educational Assistance
200 Newbury Street
Boston 16, Mass.

Massachusetts Higher Education Loan Plan (H.E.L.P.)

This plan enables the Massachusetts commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, to make available unsecured student loans. Students must be accepted by or enrolled in an institution furnishing a program of higher education which is approved by a State or Federal approving agency and by the Massachusetts Higher Education Assistance Corporation. A student who is a permanent resident of the United States may borrow up to $1,000 a year for undergraduate school, or $1,500 a year for graduate school. There is no interest charge on such loans while the student is in school, provided parental adjusted income is under $15,000. Upon leaving school there is a charge of 7% per year on the unpaid loan balance. Monthly repayment of the loan begins within one year after graduation. Loan applications are available at commercial and mutual savings banks, federal savings and loan associations, credit unions and cooperative banks, in the town of the student's residence.

Specific inquiries regarding this program should be addressed to:

Massachusetts Higher Education Assistance Corporation
511 Statler Building
Boston, Massachusetts 02116

Telephone 426-9434

Cooperative Study Program

The First Naval District has approved Lowell Technological Institute as Sponsor of its Cooperative Work-study Program at the Boston and Portsmouth Naval Shipyards.

Students will undertake a five-year program in their field of specialization - electrical, electronic, chemical, civil and mechanical engineering, increasing their experience and capabilities in subsequent on-the-job training at either shipyard. Successful students will earn the bachelor of science degree.

Information concerning this program may be obtained by

writing the First Naval District Headquarters at Charlestown or the Director of Admissions, Lowell Technological Institute.

PLACEMENT

Industrial Training Program

The Placement Office maintains two basic functions. One is to counsel the senior planning to take recruiting interviews; the other is arranging the dates of interviews for the representatives of the recruiting companies and agencies.

In the counselling process the Placement Officer reviews the student's transcript with him, discussing his points of strength and weakness. The elements of the recruiting procedure are explained so that he may be properly prepared for the ensuing interviews.

Approximately one hundred and eighty companies and government agencies recruit on the LTI campus. The companies represent a cross-section of industry in the country ranging from the so-called giants down to those of relatively small size. Geographically, they are located in the Northeast, the Southeast and the Mid-West with a few from the Far West. Thus, the seniors get fairly broad exposure to business opportunities.

SUMMER SESSION

The Summer Session is designed primarily to serve three principal areas of interest: Professional Advancement Courses for industrial personnel; Undergraduate Credit subjects for college students who require deficiency clearance or who seek advanced standing; and Precollege Refresher subjects for incoming freshmen at LTI.

The industry-sponsored professional advancement program comprises a series of specialized intensive, one- to three-week courses. The two six-week undergraduate sessions stress fundamental credit offerings in college mathematics, physics, chemistry, English, economics, electronics, mechanical engineering, accounting, marketing, management, and social studies.

Precollege Refresher Program

The Precollege Refresher Program is especially designed for prospective LTI students who require additional background to fulfill minimum entrance requirements. Students must first apply for fall admission; the Dean of Admissions designates the subject or subjects required for coverage of minor deficiencies in the high school background. Five-week, noncredit subjects in basic mathematics, physics, chemistry, and English are offered in a June-July session to accommodate all freshman candidates.

For further information or a Summer Session Bulletin, write to the Director of Summer School.

THE GRADUATE SCHOOL

The Lowell Technological Institute Graduate School, which was founded in 1935, offers advanced studies, including professional training and research leading to graduate degrees in many fields of engineering and in certain areas of pure and applied science. The School offers Master of Science degree programs in the following fields: Chemical Engineering, Chemistry, Electrical Engineering, Mathematics, Mechanical Engineering, Nuclear Engineering, Paper Engineering, Physics, Polymer Science, and Textile Technology. Programs leading to the Doctor of Philosophy are also offered in Chemistry, including a Polymer Science option, and in Physics, including Solid-State, Nuclear and High Energy options. In addition to the day classes intended primarily for full-time graduate students, the graduate School offers some evening courses through the Division of Evening Studies mainly for the convenience of part-time students primarily interested in advanced professional training. The courses offered in the evening are equivalent in every respect to those offered to the day students for they are simply evening sections of courses offered during the day. There are currently 8l graduate students enrolled in degree programs for advanced professional training in these Evening Division courses out of a total Graduate School enrollment of 266 students. These part-time students are primarily from the large industrial companies nearby the Institute located principally in the Merrimack Valley. New graduate programs in Applied Mathematics, Plastics, and Electronic Systems Engineering are currently under consideration by the Graduate School Executive Committee and it is hoped that these programs will be instituted in the Fall of 1969. Programs of this type, which would include as well as Plastics and Systems Engineering, the graduate programs in Paper, Textiles and Nuclear Engineering are in wide demand by industry in New England and in Massachusetts in particular. These programs serve as excellent supplements to the standard curricula in the basic engineering and science areas which would include Chemistry, Physics, Chemical Engineering, Electrical Engineering and Mechanical Engineering. In June of 1968, there were 36 Master of Science degrees and 1 Doctor of Philosophy degree granted through the Graduate School at LTI. For further information concerning the graduate programs, please consult the Graduate School Catalog.

SPECIAL SERVICES TO INDUSTRY AND THE COMMUNITY

In addition to the services rendered by the Evening Division, the Alumni Memorial Library, the Research Foundation, and the Summer School program, the college provides such special services to industry and to the community as the following:

Industrial seminars and conferences;
Guidance work in the high schools;
Technorama, science fair for area high schools;
Consultive opportunities with the faculty;
Collaboration with the Agency for International Development of the government in its foreign aid program;
Special radio and television programs, such as Science

For information relative to these programs, address the Coordinator of Special Services at the Institute.

DIVISION OF EVENING STUDIES

The Division of Evening Studies offers associate and baccalaureate degree programs in a variety of technical fields, and a master's degree satellite program with area industries. Additionally, individual subjects in mathematics, science, technology, engineering, and general studies may be taken by special arrangement. Selected subjects offered during the summer are conducted as part of the Professional Advancement Program.

In cooperation with the Massachusetts Division of Personnel and Standardization, the Division of Evening Studies also offers an In-Service Training Program in Civil Engineering Technology limited to employees of cities and towns within the Commonwealth.

Two semesters of 15 weeks each are offered, starting in mid-September and late in January. Selected subjects are also offered in an 8-week summer program. For further information, write to the Director of the Evening School.

RESEARCH FOUNDATION

The Lowell Technological Institute Research Foundation is a nonprofit organization authorized under the laws of the Commonwealth of Massachusetts. It was established in 1950 for the purpose of conducting research, development and testing under government and industrial sponsorship. Initially its prime purpose was to answer the needs of the Lowell Technological Institute for facilities and staff to perform basic and applied research in textiles and related subjects. As the Research Foundation expanded, a diverse and growing program of research and development activities has increased extensively, and projects have moved into the fields of chemistry, leather, paper, plastics, electronics, physics, and, more recently, oceanography, nuclear engineering and environmental pollution, in addition to management and economic development assignments.

The keynote of operation of the Research Foundation has always been its flexibility and consequent versatility in tackling diverse problems, in cooperation with the staff and faculty members of Lowell Technological Institute. The Research Foundation is presently composed of four major divisions, Electronics and Physics, Environmental Pollution, Ionospheric Science and Testing Divisions, the latter being mainly concerned with the testing and evaluation of textiles and a wide variety of other materials submitted by industry and government sources.

One of the major research activities of the Research Foundation is in the field of geophysics, with particular emphasis on

ionospheric characteristics deduced from ionosonde and satellite total electron content measurements, and spaced receiver experiments to investigate F-Region irregularities. Very intensive theoretical and experimental work has been carried out in the lower levels (D-Region) of the earth's ionosphere.

Another field of considerable interest and proven capability is in the area of optical physics. Specific research programs have included investigations in atmospheric optics, photographic sciences, spectrographic analysis and electro-optical instrumentation technology. Recent experimental and theoretical studies have considered the problems associated with imaging through a turbulent atmosphere using both coherent and incoherent illumination.

Design, development and fabrication of instrumentation systems for scientific and industrial use is conducted within the organization by the Systems Engineering Group. New circuit and measurement techniques are evaluated for suitable applications which include rocket payloads, telemetry ground stations, oceanographic and high altitude balloon instrumentation.

The latest Division to be formed within the Research Foundation is the Environmental Pollution Division. Here research is undertaken in the everwidening field of pollution abatement, together with investigation of relevant chemical and engineering problems.

Further information and descriptive literature may be obtained by writing to Mr. Dorrance H. Goodwin, Executive Director, Lowell Technological Institute Research Foundation, Lowell, Massachusetts.

ALUMNI ASSOCIATION

The Alumni Association administers numerous scholarships and fellowships, publishes the official alumni newsletter, and the alumni directory, aids student organizations, and conducts its annual business meeting and reunion in the fall of each year. Those eligible for active membership include all students who have completed satisfactorily at least one year of the day curriculum and Evening Division senior-year candidates for associate degrees who apply to become members. Only active members may vote and hold office in the Association. The Association holds membership in the American Alumni Council.

By-laws also provide for honorary and associate memberships. The Honorary Membership Scroll and Citation may be awarded by the Board of Directors to any person not an active member who has made outstanding contribution to the arts or sciences. Any person not otherwise eligible for membership who has made significant contribution to the welfare of the Institute may be elected to associate membership by the Board

of Directors. The Honorary Award Scroll and Citation may be awarded by the Board of Directors to any active member of the Association who has made outstanding contribution to the arts of sciences.

Communications should be addressed to the Executive Secretary, Alumni Office, Lowell Technological Institute.

STUDENT ACTIVITIES

Student Council

The Student Council is the chief body for self-government in student affairs. It is composed of four executive officers elected by the student body and the officers of each class. It exercises administrative control over all campus organizations, represents the student body in matters requiring conferences with the administration and faculty, investigates student grievances, sponsors all-campus social affairs, and supervises the expenditure of the unallocated portion of the student activity fee.

Alpine Club

Composed of students interested in mountain climbing, skiing, and associated sports. Numerous weekend trips are scheduled throughout the year. Highlight of the club is the week-long skiing trip during the semester break.

Amateur Radio Club

This organization is enjoined to promote the fraternity of Amateur Radio at Lowell Tech and specifically to promote the fellowship of amateur radio through on-the-air activities. To aid interested individuals in obtaining their amateur radio license as well as helping current license holders advance their grades.

Angel Flight

Angel Flight is the co-ed auxiliary to and is sponsored by the Vandenberg Air Squadron of the Arnold Air Society. It is primarily a service organization. Its objectives are to advance and promote interest in the Air Force, obtain information regarding military services, and aid the progress of the Arnold Air Society at the Institute.

Athletics and Recreation

The Athletic Association is funded by student fees and provides extensive opportunities for student participation in Intercollegiate, Intramural and Recreation programs. All students are members of the Association and are admitted free to all home athletic contests.

Intercollegiate Athletics: Lowell Tech has intercollegiate competition in seventeen sports. Teams are scheduled in Soccer and Cross Country in the fall, Basketball, Hockey, Wrestling, Gymnastics, Swimming, Skiing, Squash, Bowling and Rifle in the Winter; Baseball, Track, Golf, Tennis, Crew and Lacrosse in the Spring. Varsity and freshman teams are provided in most cases except for the few sports conducted on a club basis in which freshmen may participate on the varsity team.

Intramurals: The Intramural program at L.T.I. is extensive. The three leagues — Fraternity, Dormitory and Independent — compete in the following activities: Touch Football, Tennis, Golf, Bowling, Track, Cross Country, Ice Hockey, Speed Skating, Handball, Squash, Volleyball, Badminton, Water Basketball, Table Tennis, Six-Man Soccer and Six-Man Lacrosse. An intramural Handbook describes the program in detail.

Recreation: The athletic facilities at L.T.I. are open for student use from 8:00 a.m. to 9:30 p.m. weekdays, and from l0:00 a.m. to 3:00 p.m. on Saturdays.

There are opportunities for student participation in the organized and informal recreational activities listed as follows: Badminton, Volleyball, Basketball, Physical Conditioning, Swimming, Diving, Water Basketball, Life Saving, Archery, Table Tennis, Touch Football, Skin and Scuba Diving, Wrestling, Judo, Karate, Rifle and Pistol Shooting, Weight Training, Gymnastics, Handball, Squash, Tennis, Ice Skating, Track and Field, Softball and Lacrosse.

Equipment needed for most of these sports is available from the Issue Room on presentation of the student's ID card.

Students are urged to supplement their required activities with a regular program of recreation.

Audio-Visual Society and Radio Station WLTI

The Audio-Visual Society was formed on the campus in the academic year 1959-1960 for the purpose of providing film and musical programs for the students and faculty of L.T.I. The constitution was redrawn in the fall of 1963 to include carrier current radio station WLTI (650 kc.) as the Broadcasting Services Branch, and incorporated a Technical Services Branch in addition to the original Audio-Visual Services Branch.

The new library addition has extensive audio-visual facilities including offices, workshops, master control, individual and group listening rooms, a multipurpose room and radio studios.

WLTI was originally organized as The Lowell Tech Broadcasting Society, and first went on the air in 1953. In 1965, a giant step toward the dream of an educational FM station was realized with the gift of a 10 Kw FM transmitter. Work is now under way on the renovation of this equipment and the licensing of the station. Both stations will have new studios and quarters on the ground floor of the library. Operation of these facilities will require the efforts of a skilled engineering staff. Programming, announcing, advertising and publicity will call for a large student staff.

The Technical Services Branch was added to A.V.S. in 1963 for the purpose of maintaining and repairing the technical equipment used by the society. This department also has the

responsibility of designing and modifying all new equipment, and offers an interesting challenge to technically minded students.

Many openings are available in the Society for the student interested in enhancing his education while serving the institute. Also important is the opportunity to work with fellow students and faculty members. Membership is open at all times; interest is the only prerequisite.

Band

Band membership is open to all students who possess musical training or wish to learn to play a band instrument.

Cheerleaders

The Cheerleaders encourage and promote the enthusiasm of the Student Body as well as that of the team members at L.T.I. basketball games.

Chess Club

Students and faculty members participate in the Chess Club which promotes tournaments with chess clubs in other colleges. Discussions are held on methods of attack and counterattack in chess as played in other countries.

Chinese Students Circle

The aims of this organization are to render assistance to newly arrived Chinese students at L.T.I., to promote and interpret on campus the culture and life of China, to encourage members to participate more fully in the extra-curricular activities on campus and in the Boston area, and to share common interests and develop understanding and social contact among the Chinese students at the Institute.

Circle K

This club is the student chapter of Kiwanis. Besides performing many services in the public interest, the members assist the administration in the annual freshman orientation program and provide tutorial help to freshman.

Interdormitory Council

This Council arranges social, athletic, and scholastic activities for resident students after academic hours and acts as a liaison between residents and the administration to maintain proper deportment and living conditions.

Eta Kappa Nu

To be eligible for membership in this scholastic honor so-

ciety, one must be an Electrical Engineering major who has participated in campus activities and is of exemplary character. Juniors must be in the upper quarter of their class, and seniors must be in the upper third of their class. The purpose of the organization is to provide a closer union for students majoring in Electrical Engineering who have achieved high scholastic standing, demonstrated leadership in campus activities, and possess outstanding character.

Fraternities

There are fraternities — Delta Kappa Phi, Kappa Sigma, Omicron Pi, Phi Gamma Psi, Pi Lambda Phi, Sigma Phi Omicron, and Tau Kappa Epsilon — all but one have their own houses. All provide social life off campus and four are national fraternity affiliates. The Inter-fraternity Council fosters the common interests of the seven and sponsors interfraternity social and athletic events.

Graduate Club

An organization to promote interdisciplinary understanding and provide a social program for Graduate students and Graduate faculty of LTI.

Indian Students' Association

Composed of students from India, this organization conducts social and cultural events throughout the year, several of them open to the public.

International Students Circle

All students from other countries are invited to join this organization which endeavors to help each foreign student to adjust to a new language or way of living. Members frequently are guests of local civic groups and serve as speakers on many programs outside the Institute.

Karate Club

Instruction in Karate is made available to members of this organization.

Latin-American Society

This organization unites students of Latin-American origin in a cultural and social program.

Pershing Rifles

This national society is dedicated to the encouragement, preservation, and development of the highest ideals of the military profession. One of its activities is participation in several meets during the year as the AFROTC Armed Drill Team. Competition includes other AFROTC units as well as Army and Navy Pershing Rifles units.

Pickout

The Pickout is the college yearbook. Its staff is wholly responsible for the editorial, graphic, and business problems involved in the production of a top-quality, photo-literary history of the academic year.

Professional Societies

The following societies make frequent field trips to industrial plants and conduct monthly meetings at which students and guest speakers present technical papers and lectures:

American Association for Textile Technology, Student Chapter

American Chemical Society, Student Chapter

American Nuclear Society, Student Chapter

American Society of Mechanical Engineers, Student Chapter

American Society of Tool and Manufacturing Engineers, Student Chapter

Chemical Engineering Society

Industrial Management Society

Institute of Electrical and Electronics Engineers, Student Chapter

MALTI (Mathematics Association of LTI)

Sigma Kappa Psi

Society for Advancement of Management, Student Chapter

Society of Physics Students

Society of Plastics Engineers, Student Chapter

TAPPI (Student Chapter, Tech. Association of Pulp & Paper Industry)

Religious Groups

Christian Science Organization

The purpose of the Christian Science Organization is to provide for all interested students the opportunity to learn of Christian Science and its application to student life. Activities of the organization include weekly meetings, an organization-sponsored lecture, and informal meetings with Christian Scientists from other colleges.

Hillel.

The Hillel Counsellorship provides social, cultural, and religious programs for Jewish students at the Institute. Business sessions, discussion groups, socials, and guest speakers are presented. Hillel is sponsored by the national B'nai B'rith organization.

Iona Student Fellowship

Iona includes students and faculty members of various races and creeds united in common fellowship to attempt to understand the will of God through worship, study, and action and to realize it both in personal living and in working toward a better society.

Newman Community

Through the combined efforts of the spiritual advisors and many local friends, the Newman Community now has a Newman Center located at 52 Colonial Avenue (in the immediate vicinity of the campus). A student lounge with a library for study and a rumpus room with piano and Hi Fi system are available for student recreation. The center is open to all students of LTI, Lowell State College, and Lowell General Hospital School of Nursing from 10:00 a.m. to 1:00 a.m., Monday through Friday. Discussion groups and meetings with the Chaplains are in progress weekly, and all students are urged to visit and participate in the many programs now offered at the Newman Center.

Phanar Club

This is composed of Greek Orthodox students from Lowell State College and LTI.

Rifle and Pistol Club

Membership in the Rifle and Pistol Club is open to all students and faculty at LTI. The purpose of this organization is to promote and facilitate the shooting sports among members.

Rowing Club

The LTI Rowing Club introduces LTI students to the techniques, training, and physical fitness required for competitive crew. Full fall and spring schedules provide races against schools, clubs, and colleges under the auspices of both The National Association of Amateur Oarsmen and The New England Amateur Rowing Association. Full coaching is provided for newcomers to the sport.

Skindiving Club

Non-divers are taught the safety measures involved by experienced divers who also skindive as a group.

Society of Afro-Americans

This organization assists and organizes whatever separate groups and/or function that will allow those individuals dedicated to the benevolent welfare of black people to invest their energies.

Sorority

Phi Sigma Rho, the campus sorority, provides a center for the social life and association of the young women enrolled at the Institute.

Sports Car Club

This club promotes the safe, courteous, efficient, and skillful operation of sports cars on the highway and is a source of information for members.

Student Wives Club

The purpose of this organization is to provide a common meeting ground for students' wives, to share the problems unique to students' wives, to assist newcomers to the Lowell area, to promote friendship and to provide "low budget" entertainment for married couples on campus.

Tau Epsilon Sigma

Membership in Tau Epsilon Sigma, the scholastic honor society at the Institute, is open to seniors and juniors who are elected on the basis of outstanding scholastic achievement and character.

Tech Players

All theatrical activities of the Institute are centered around the Tech Players. Their annual production is a high point in the social calendar, and during the year the Players bring one-act plays to the public at service clubs and on hospital visits.

The Text

The Text, the campus newspaper, is prepared and edited by students. The bi-monthly publication offers excellent journalistic and business experience to those who work on its staff.

Vandenberg Air Squadron of the Arnold Air Society.

The Vandenberg Air Squadron, a chapter of the national Arnold Air Society, unites selected Professional Officer Course AFROTC cadets by a fraternal bond to further the mission and traditions of the Air Force. The society provides social affairs and aerospace exhibits during the year. The Military Weekend, annual highlight of its program, is climaxed by the formal Military Ball at which time new members are accepted into the society.

Varsity Club

The Varsity Club is composed of students who have earned letters in the intercollegiate sports, baseball, basketball, golf, soccer, and tennis. Its purpose is to give academic help to athletes and to foster a lasting friendship among the men participating in athletics.

Veterans Club

The objectives of this club shall be to present programs of interest and importance to the membership of the club, to service all veterans whether or not they are members of the organization, to assist members in finding part-time and summer employment, and to actively participate and become interested in academic and non-academic areas of concern within the Institute.

THE AIR FORCE ROTC PROGRAM

The program is designed to qualify for commissions those men who desire to serve in the United States Air Force, and to provide an education that will develop skills and attitudes vital to professional Air Force officers.

The Air Force ROTC program is divided into two phases: the General Military Course (GMC) the first two college years and the Professional Officer Course (POC), the last two years.

A student may elect to enroll in the Two-Year AFROTC Program or the Four-Year AFROTC Program. A student electing the Four-Year Program will take the General Military Course during his freshman and sophomore years and the Professional Officer Course during his junior and senior years. He will attend four weeks of field training during the summer between his junior and senior years. As a member of the four-year program he is eligible to compete for the equivalent of a scholarship through the Financial Assistance Program. For acceptance into the POC the Four-Year Program student must pass a physical examination, an Officer Qualification Test, and possess an acceptable academic rating. To qualify for enrollment in the Two-Year Program, a student must have two academic years remaining at either the graduate or undergraduate level or a combination of the two. He must also meet certain physical standards, pass an Officer Qualification Test, and possess an acceptable academic rating. Further, he must successfully complete a six weeks Field Training Course before he can be accepted into the Professional Officer Course. Students in the Two-Year Program are not eligible to compete for the AFROTC Financial Assistance Program. Transfer students may elect the Professional Officer Course by satisfying the above requirements.

Uniforms and all equipment and textbooks required for AFROTC work are supplied by the Institute and the United States Air Force. Students in the Professional Officer Course receive a $50.00 a month subsistance fee. Additionally, financial assistance grants are available to a limited number of cadets in the four-year program on a competitive basis.

Students who successfully complete the Professional Officer Course are commissioned as second lieutenants in the United States Air Force Reserve. Those who qualify may receive further training after commissioning in scientific skills, pilot or navigator training, or administration. Outstanding seniors who are designated Distinguished AFROTC Cadets may apply for regular commissions.

GENERAL MILITARY COURSE

FRESHMAN YEAR

	First Semester	
AS 101	World Military Systems I	(1-1) 1
	Second Semester	
AS 102	World Military Systems II	(1-1) 1

SOPHOMORE YEAR

	First Semester	
AS 201	World Military Systems III	(1-1) 1
	Second Semester	
AS 202	World Military Systems IV	(1-1) 1

PROFESSIONAL OFFICER COURSE

JUNIOR YEAR

	First Semester	
AS 301	Growth and Development of Aerospace Power I	(3-1) 3
	Second Semester	
AS 302	Growth and Development of Aerospace Power II	(3-1) 3

SENIOR YEAR

	First Semester	
AS 401	The Professional Officer I	(3-1) 3
	Second Semester	
AS 402	The Professional Officer II	(3-1) 3

Subjects required in the AFROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects required in the AFROTC program in the junior and senior years may be substituted for General Electives in all curricula unless otherwise specified.

CORPS TRAINING

Corps Training is conducted one hour each week. This is an assembly of the entire cadet corps under the drrection of the

cadet officers and staff wherein the General Military Course cadets learn the rudiments of marching and drill and the Professional Officer Course cadets develop their capability to lead, supervise and command marching troops.

FIELD TRAINING

Field Training is held at several Air Force operational bases each summer where cadets have the opportunity to observe, fly and live with career personnel. Transportation from the legal residence of the cadet to the Field Training Base and return, food, lodging and medical and dental care are provided by the Air Force. In addition, the cadet receives approximately $138.00 for the four week Field Training and $131.00 for the six week Field Training.

FIELD TRIPS

Periodically, the Department of Aerospace Studies conducts field trips to various Air Force installations. These trips include tours of the base and familiarization flights. Efforts are made also to assist those cadets who are interested in flying to gain as much information as possible about this phase of the Air Force.

FLIGHT INSTRUCTION

The Flight Instruction Program (FIP), designed for seniors in the Professional Officer Course who plan to enter Air Force pilot training upon graduation, determines whether applicants have the necessary qualifications to fly high-performance aircraft. The program consists of two phases. The ground phase, given by officers of the detachment, serves to familiarize each student with procedures in navigation, radio and weather. The flying phase consists of 36½ hours of flight instruction at government expense.

CADET DECORATIONS AND AWARDS

A number of medals are awarded to selected cadets and cadet officers at a special parade and review held each spring. These include the Thomas F. Costello Trophy, the Alumni Medal, the Armed Forces Communications and Electronics Association Award, the Sons of the American Revolution ROTC Award, the Trustees' Medal, the Reserve Officer Association Medal, the Air Force Association Medal, the "Air Force Times" Award, and the Vandenberg Cup.

In addition, the Department of Aerospace Studies confers several medals and awards for outstanding performance in various fields, among them the Distinguished Military Cadet Awards.

Distinguished AFROTC Graduate Awards are given to outstanding graduates, based on academic and military achievements. A recipient of this award may apply for a regular commission as a Second Lieutenant in the United States Air Force.

PHYSICAL EDUCATION

Physical Education contributes to the college curriculum through specific programs of physical fitness, sports, recreational games, gymnastics, tumbling, aquatics, wrestling and judo.

The following objectives serve as guides for the program:

1. The improvement of health through increased organic vigor.
2. The development of efficient and effective sports skills and motor fitness.
3. The development of desirable social attitudes and standards of conduct.
4. The development of an appreciation for and interest in physical activities which will result in continued participation in wholesome and enjoyable leisure pursuits.

Undergraduates must successfully complete two semesters of Physical Education. The semesters are divided into quarters in order to expose students to diverse activities. Classes meet for two one hour periods each week. The Physical Education requirement should be met during the freshman year.

A swimming test is administered to the students during freshman Orientation Week. Students, who fail this test are assigned Swimming for Beginners, P.E. 160. All students in the Physical Education Program shall pass a minimal swimming test before completing their Physical Education requirement.

Next, a Physical Fitness Test is given. Students, who do not meet the minimal satisfactory scores in three (3) of the four (4) test items are assigned Physical Fitness, P.E. 110 for the first quarter. Students, who pass the test are allowed to choose from a list of activities which are offered for each quarter. The Physical Fitness classes are retested at the end of the quarter; students who pass, are then also allowed to choose areas of activities for ensuing quarters.

Participation in varsity and club sports is an integral part of the Physical Education Program; therefore, recognition will be given for such participation.

INDIVIDUAL ACTIVITIES

P.E. 110	Physical Fitness
P.E. 115	Individual Sports (handball-squash-paddle racquets)
P.E. 120	Weight Training
P.E. 125	Gymnastics & Tumbling

II TEAM ACTIVITIES

P.E. 130	Basketball
P.E. 135	Hockey
P.E. 140	Soccer
P.E. 145	Softball
P.E. 150	Touch Football
P.E. 155	Volleyball

III AQUATICS

P.E. 160	Swimming for Beginners
P.E. 161	Intermediate Swimming
P.E. 162	Pre Life-saving
P.E. 163	Life Saving
P.E. 164	Competitive Swimming
P.E. 165	Competitive Diving

IV COMBATITIVES

P.E. 170	Judo
P.E. 175	Wrestling

UNDERGRADUATE PROGRAMS

Sixteen fields of study are open to undergraduates. All are four years in length and lead to the degree of Bachelor of Science. These fields are:

Biological Sciences	Mechanical Engineering
Business Administration	Meteorology
Chemical Engineering	Nuclear Engineering
Chemistry	Paper Engineering
Civil Engineering	Physics
Electrical Engineering	Plastics Technology
Industrial Management	Textile Engineering
Mathematics	Textile Technology

These curricula, outlined in the following pages, are under constant study and are subject to revision whenever changes are necessary in the best interests of the Institute and students.

A special curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering is open as an In-Service Training Program for employees of the Commonwealth of Massachusetts. Regulations for entrance into this program and subjects required prior to attending day classes as in-residence students are shown in the Catalogue of the Division of Evening Studies of the Lowell Technological Institute.

Four-year curricula leading to the degree of Bachelor of Science in Engineering Technology are in the process of being developed in most of the above fields of engineering. Announcements will be made when they become available.

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

Some undergraduate subjects may be taken for graduate credit. Consult the Graduate School catalogue for details.

THE ELECTIVE SYSTEM

In all curricula an opportunity is given the student to elect subjects in addition to those required for graduation. These fall into two categories: Technical Electives and General Electives.

Technical Electives give the student a chance to broaden his professional knowledge by taking courses allied to his field of concentration or to further his knowledge of a particular phase by additional work therein.

Prior to the registration period for each semester, a list of the General Electives to be offered is made available to faculty and students. *To ensure fulfillment of degree requirements and accreditation standards, all General Elective choices must be approved by the Department Head or the Advisor in the curriculum in which the student is a degree candidate.*

Subjects taken in the United States Air Force ROTC program in the freshman and sophomore years are in addition to all other subjects listed in the various curricula. They may not be considered as substitutes for electives. However, subjects taken in the junior and senior years in the ROTC program may be substituted for General Electives in all curricula, *unless otherwise specified.*

EC 302	Labor Economics	(3-0)3
EC 303	Microeconomic Theory	(3-0)3
EC 304	Macroeconomic Theory	(3-0)3
EC 402	Government and Business	(3-0)3
EC 403	International Trade Theory	(3-0)3
EC 404	Comparative Economic Systems	(3-0)3
EC 407	Econometrics	(3-0)3
EC 408	History of Economic Thought	(3-0)3
EC 410	Economic Development of Less Developed Countries	(3-0)3
EC 412	Managerial Economics	(3-0)3
EC 414	Engineering Economy	(3-0)3
LL 209 or 210	Technical and Scientific Communication	(3-0)3
LL 213	Introduction to English Literature: To 1798	(3-0)3
LL 214	Introduction to American Literature: From 1865	(3-0)3
LL 215	Introduction to American Literature: To 1865	(3-0)3
LL 216	Introduction to English Literature: From 1798	(3-0)3
LL 218	Negro-American Literature	(3-0)3
LL 233	Comparative Literature	(3-0)3

LL 234 or 235	Shakespeare	(3-0)3
LL 259-260	Elementary German	(3-0) (3-0)6
LL 261-262	Elementary Technical German	(3-0) (3-0)6
LL 263-264	Elementary French	(3-0) (3-0)6
LL 265-266	Elementary Russian	(3-0) (3-0)6
LL 267-268	Elementary Spanish	(3-0) (3-0)6
LL 269-270	Elementary Modern Greek	(3-0) (3-0)6
LL 311	Advanced Composition	(3-0)3
LL 313	Introduction to Continental Literature	(3-0)3
LL 314	Continental Literature Since the Renaissance	(3-0)3
LL 316	The English Bible as Literature	(3-0)3
LL 333 or 334	Problems of Philosophy	(3-0)3
LL 341 or 342	Satire	(3-0)3
LL 344	Modern Poetry	(3-0)3
LL 345	Modern Irish Literature	(3-0)3
LL 363-364	Intermediate French	(3-0) (3-0)6
LL 365-366	Intermediate Literary and Conversational Russian	(3-0) (3-0)6
LL 367-368	Intermediate German	(3-0) (3-0)6
LL 369-370	Intermediate Spanish	(3-0) (3-0)6
LL 435	English Literature of the Eighteenth Century	(3-0)3
LL 436	English Romantic Poets	(3-0)3
LL 437	English Literature of the Victorian Period	(3-0)3
LL467 or 468	Seminar in German Masterpieces	(3-0)3
LL 471	The Modern American Novel	(3-0)3
LL 472	The Modern British Novel	(3-0)3
LL 473	World Drama	(3-0)3
LL 474	Modern Drama	(3-0)3
LL 476	Nineteenth-Century British Novel	(3-0)3
LL 482	The American Short Story	(3-0)3
LL 495 or 496	Reading and Research	(3-0)3
SS 223	The United States: 1865-1912	(3-0)3
SS 224	The United States: 1912 to the Present	(3-0)3
SS 225	Europe: 1789-1914	(3-0)3
SS 227	Europe: 1914-1939	(3-0)3
SS 228	Europe: 1939 to the Present	(3-0)3
SS 301	Government of the United States	(3-0)3
SS 302	Conduct and Control of Foreign Policy	(3-0)3
SS 303 or 304	Psychology	(3-0)3
SS 305 or 306	Sociology	(3-0)3
SS 307	Seminar in Sociology	(3-0)3
SS 371 or 372	American Civilization to 1865	(3-0)3

SS 403	Psychological Warfare	(3-0)3
SS 459	World Politics: The Central Problem of War	(3-0)3
SS 471	The United States in World Politics	(3-0)3
SS 472	Defense Policy	(3-0)3
SS 477	Russia: The Empire	(3-0)3
SS 478	Russia: The Soviet Union	(3-0)3
SS 479	The Far East Since 1842	(3-0)3
SS 480	Modern China: 1644 to the Present	(3-0)3
SS 483	Political and Social Thought: The Greeks and the Romans	(3-0)3
SS 484	Political and Social Thought: 400 A.D.-1600 A.D.	(3-0)3
SS 485	Political and Social Thought: 1600-1800	(3-0)3
SS 486	Political and Social Thought: 1800 to the Present	(3-0)3
SS 487	American Political Thought to 1865	(3-0)3
SS 488	American Political Thought Since 1865	(3-0)3
SS 492	Twentieth Century Germany	(3-0)3
SS 495	The Technological Future: The Material Aspects	(3-0)3
SS 496	The Technological Future: The Social and Political Aspects	(3-0)3
SS 497 or 498	Seminar: History or Political Science	(3-0)3
SS 499	Science and Religion: Science as a Social System	(3-0)3
SS 500	Science and Religion: Religion as a Social System	(3-0)3
SS 502	Afro-American History	(3-0)3

THE FRESHMAN PROGRAM

The first week's program in the fall for entering freshmen is called Freshman Week. It is devoted to facilitating adjustment of the new student to his physical, social, and academic surroundings. Under the sponsorship of the Office of the Dean of Students, a program of meetings, lectures, and conferences is presented in order to acquaint the entering class with the traditions, customs, rules and regulations, courses of instruction, organizations, recreational activities, and other facilities of Lowell Technological Institute.

All freshmen except those enrolled in Business Administration* or Industrial Management,** take the following subjects:

First Semester

CH	001	Chemical Principles	(4-0)3
CH	003	Chemical Principles Laboratory	(0-2)1
LL	111	English I	(3-0)3
MA	103	Calculus I	(3-0)3
PH	101	Physics	(4-1)4
		Total hours	(14-3)14

Second Semester

CH	002	Chemical Principles	(4-0)3
CH	004	Chemical Principles Laboratory	(0-2)1
LL	112	English II	(3-0)3
MA	104	Calculus II	(3-0)3
ME	104	Design Graphics	(1-0)1
PH	102	Physics	(4-2)4
		Total hours	(15-4)15

In addition to the preceding schedule all nonveteran men students who are physically qualified must take physical education two hours per week during the entire freshman year. No academic credit is given for the physical education program.

*The freshman program in Business Administration is given on the page outlining the curriculum.

**Majors in Industrial Management substitute EC 201, Economics I (3-0)3, for PH 101, and EC 202, Economics II (3-0)3, for PH 102.

BIOLOGICAL SCIENCES

The curriculum in the Biological Sciences is designed to provide a sequence of liberal arts and science courses for a sound career foundation.. Development of attitudes along with abilities is considered highly significant for a successful career. The importance of a breadth of knowledge and understanding of related scientific disciplines is stressed for greater appreciation and comprehension of biological principles and modern quantitative concepts.

Upon graduation the biology major will find opportunities in teaching, industry, government and the medical services. The curriculum objectives chosen permit a sound preparation for graduate study in the biological sciences, medicine and dentistry.

A written comprehensive examination is required of all majors. Students who have demonstrated high scholastic ability may conduct independent studies throughout the senior year. Emphasis is placed on completion of an original research project followed by an oral examination of the candidate's major courses and undergraduate thesis.

SOPHOMORE YEAR

First Semester

BI	201	Principles of Biology	(3-3)4
CH	221	Organic Chemistry	(3-4)4
LL	261	Elementary Technical German	
		or	
LL	263	Elementary French	
		or	(3-0)3
LL	265	Elementary Russian	
		or	
LL	267	Elementary Spanish	
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(16-9)18

Second Semester

BI	202	Principles of Biology	(3-3)4
CH	222	Organic Chemistry	(3-4)4
LL	262	Elementary Technical German	
		or	
LL	264	Elementary French	
		or	(3-0)3
LL	266	Elementary Russian	
		or	
LL	268	Elementary Spanish	
		Two General Electives*	(6-0)6
		Total hours	(15-7)17

*LL 334 (Problems of Philosophy) and
SS 304 (Psychology) are recommended.

JUNIOR YEAR

First Semester

BI	301	Physiology	(3-3)4
BI	311	Microbiology	(3-3)4
CH	335	Principles of Physical Chemistry	(3-3)4
MA	383	Statistical Methods	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-9)18

Second Semester

BI	330	Ecology	(3-3)4
CH	336	Principles of Physical Chemistry	(3-3)4
CH	422	Biochemistry	(3-3)4
		Technical Elective*	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-9)18

*BI 370 (Genetics) or MA 360 (Digital Computer Programming) recommended.

SENIOR YEAR

First Semester

BI	411	Research in Biology or Biology Elective	4
BI	451	Seminar in Biology	(1½-0)1
RS	441	Radioisotope Techniques	(3-3)4
		Technical Elective	4
		General Elective	(3-0)3
		Total credit hours	16

Second Semester

BI	412	Research in Biology or Biology Elective	4
BI	452	Seminar in Biology	(1½-0)1
BI	462	Radiation Biology	(3-0)3
		Technical Elective	4
		General Elective	(3-0)3
		Total credit hours	15

BUSINESS ADMINISTRATION

The major objective of the curriculum in Business Administration is to provide an undergraduate professional education for young men and women who have the qualifications and the ambition to be administrators and executives.

The common aspects of the curriculum offer an integration of the traditional liberal arts subjects and those professional subjects which provide the basic foundations of management science. The emphasis is not technical but administrative. A common core of business and economic subjects — accounting, economics, finance, business law, marketing, production, statistics — is required of all students. An extensive selection of courses in languages and literature, the humanities and mathematics, broadens each student's intellectual capacity.

After a common freshman year each student is required to select a major track of study. These are: accounting, economics, and management. The management area is further subdivided into financial management, marketing management, and production management.

Freedom is provided in elective course selection but not to the degree that overspecialization is possible at this undergraduate level. The goal of the program is broad professional competence with a modest degree of specialization in one area.

FRESHMAN YEAR

First Semester

BA	141	Accounting I	(3-0)3
BA	191	Science and Industry I	(3-0)3
EC	201	Economics I	(3-0)3
LL	111	English I	(3-0)3
MA	101	Mathematical Analysis I	(3-0)3
		Total hours	(15-0)15

Second Semester

BA	142	Accounting II	(3-0)3
BA	192	Science and Industry II	(3-0)3
EC	202	Economics II	(3-0)3
LL	112	English II	(3-0)3
MA	102	Mathematical Analysis II	(3-0)3
		Total hours	(15-0)15

All nonveteran male students who are physically qualified must take physical education two hours per week during the entire freshman year. No academic credit is given.

ELECTIVE COURSE GUIDELINES FOR ALL BA OPTIONS

Behavioral Science: The student may select any SS courses in Psychology and Sociology.

Humanities: Where a humanities elective is indicated a student may select any course bearing an EC, LL, or SS prefix not required in his curriculum. If the student is in the advanced Air Force R.O.T.C. program he will substitute AS 301, 302, 401, and 402, for the humanities electives normally taken in the junior and senior years.

Languages and Literature: In the sophomore year each student must elect two courses given with an LL prefix. If a foreign language offering is chosen, the student will have to have two years for credit. He may use the humanities electives provided for in his junior year for this purpose.

Management: The student, with the advice and consent of his Faculty Advisor, will select an area of concentration (finance, marketing, or production), and will take a minimum of four courses in that area. Where indicated, he may select additional management courses in his concentration area or in the other management disciplines. Overspecialization is not recommended at the undergraduate level.

ACCOUNTING OPTION
SOPHOMORE YEAR
First Semester

BA	241	Accounting III	(3-0)3
BA		Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
MA		Mathematical Analysis III	(3-0)3
		LL Elective	(3-03
		Total hours	(15-0)15

Second Semester

BA	242	Accounting IV	(3-0)3
EC	212	Economic Statistics II	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
		Behavioral Science Elective	(3-0)3
		LL Elective	(3-0)3
		Total hours	(15-0)15

JUNIOR YEAR
First Semester

BA	332	Money and Banking	(3-0)3
BA	341	Accounting V	(3-0)3
BA	362	Business Law	(3-0)3
BA	371	Production Management I	(3-0)3
BA	481	Insurance	(3-0)3
		Humanities Elective	(3-0)3
		Total hours	(18-018

Second Semester

BA	331	Business Finance	(3-0)3
BA	342	Accounting VI	(3-0)3
BA	344	Cost Accounting	(3-0)3
BA	363	Advanced Business Law	(3-0)3
BA	372	Production Management II	(3-0)3
		Humanities Elective	(3-0)3
		Total hours	(18-0)18

SENIOR YEAR
First Semester

BA	403	Electronic Data Processing	(3-0)3
BA	441	Auditing	(3-0)3
BA	444	Advanced Cost Accounting	(3-0)3
BA	451	Personnel Management	(3-0)3
		Management Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total hours	(18-0)18

Second Semester

BA	445	Tax Accounting	(3-0)3
BA	452	Industrial Relations	(3-0)3
BA	492	Transportation	(3-0)3
EC	402	Government and Business	(3-0)3
EC	412	Managerial Economics	(3-0)3
		Humanities Elective	(3-0)3
		Total hours	(18-0)18

ECONOMICS OPTION
SOPHOMORE YEAR
First Semester

BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
EC	303	Microeconomic Theory	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
SS	305	Sociology	(3-0)3
		Total hours	(15-0)15

Second Semester

EC	212	Economic Statistics II	(3-0)3
EC	304	Macroeconomic Theory	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
SS	301	Government of the United States	(3-0)3
SS	303	Psychology	(3-0)3
		Total hours	(15-0)15

JUNIOR YEAR
First Semester

BA	332	Money and Banking	(3-0)3
BA	362	Business Law	(3-0)3
BA	371	Production Management I	(3-0)3
EC	301	Economic Development of the United States	(3-0)3
EC	407	Econometrics	(3-0)3
		LL Elective	(3-0)3
		Total hours	(18-0)18

Second Semester

BA	331	Business Finance	(3-0)3
BA	346	Managerial Accounting	(3-0)3
BA	372	Production Management II	(3-0)3
EC	302	Labor Economics	(3-0)3
EC	404	Comparative Economic Systems	(3-0)3
		LL Elective	(3-0)3
		Total hours	(18-0)18

SENIOR YEAR
First Semester

BA	403	Electronic Data Processing	(3-0)3
BA	451	Personnel Management	(3-0)3
BA	481	Insurance	(3-0)3
EC	402	Government and Business	(3-0)3
		Economics Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total hours	(18-0)18

Second Semester

BA	492	Transportation	(3-0)3
EC	408	History of Economic Thought	(3-0)3
EC	412	Managerial Economics	(3-03
		Economics Electives	(6-0)6
		Humanities Elective	(3-0)3
		Total hours	(18-0)18

Economics Electives: EC 403, 409, 410, 411, 500.

MANAGEMENT OPTION
SOPHOMORE YEAR

First Semester

BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
MA	201	Mathematical Analysis III	(3-0)3
		Behavioral Science Elective	(3-0)3
		LL Elective	(3-0)3
		Total hours	(15-0)15

Second Semester

EC	212	Economic Statistics II	(3-0)3
EC	301	Economic Development of the United States	(3-0)3
MA	202	Mathematical Analysis IV	(3-0)3
		Behavioral Science Elective	(3-0)3
		LL Elective	(3-0)3
		Total hours	(15-0)15

JUNIOR YEAR

First Semester

BA	332	Money and Banking	(3-0)3
BA	362	Business Law	(3-0)3
BA	371	Production Management I	(3-0)3
EC	303	Microeconomic Theory	(3-0)3
		Management Elective	(3-0)3
		Humanities Elective	(3-0)3
		Total hours	(18-0)18

Second Semester

BA	331	Business Finance	(3-0)3
BA	346	Managerial Accounting*	(3-0)3
BA	372	Production Management II	(3-0)3
		Humanities Elective	(3-0)3
		Management Electives	(6-0)6
		Total hours	(18-0)18

*Production majors must take BA 344, Cost Accounting

SENIOR YEAR

First Semester

BA	403	Electronic Data Processing	(3-0)3
BA	451	Personnel Management	(3-0)3
EC	402	Government and Business	(3-0)3
		Management Electives*	(6-0)6
		Humanities Elective	(3-0)3
		Total hours	(18-0)18

*Production majors must take BA 444 — Advanced Cost Accounting

Second Semester

BA	452	Industrial Relations	(3-0)3
BA	492	Transportation	(3-0)3
EC	412	Managerial Economics	(3-0)3
		Management Electives	(6-0)6
		Humanities Elective	(3-0)3
		Total hours	(18-0)18

CHEMICAL ENGINEERING

The chemical process industries have provided over the years a strong and continued growth with an increasing demand for chemical engineering graduates. Current shortages of chemical engineers are expected to persist for many years, leading to a substantial increase in salaries and opportunities. The stability and financial attractiveness of the chemical and allied industries opens up unparalleled challenges and growth prospects for the chemical engineer.

The broad chemical and engineering training provided in this curriculum permits the chemical engineering graduate to enter Research and Development, Production, Sales, Marketing and General Management. It also gives him the tools to develop a career which is both stimulating and satisfying.

An effort is made to give the student a strong scientific background in the first two years, followed by two years of training in the discipline and related engineering subjects. The curriculum provides considerable flexibility for the student, and offers those students who wish to take advantage of the program an opportunity to do individual and original research in a variety of subjects. Considerable emphasis is placed on oral and written expression so necessary in the business world by providing term reports and other reports on technical subjects.

The chemical engineering program provides the student with a splendid background either to enter industry or graduate school upon graduation.

SOPHOMORE YEAR

First Semester

CH	223	Introductory Organic Chemistry	(3-3)4
CN	203	Introduction to Chemical Engineering	(3-0)3
CN	205	Chemical Engineering Laboratory I	(0-3)1
EC	201	Economics I	(3-0)3
MA	203	Calculus III	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
		Total hours	(16-9)19

Second Semester

CH	224	Introductory Organic Chemistry	(3-3)4
CN	204	Chemical Engineering Calculations	(3-0)3
EC	202	Economics II	(3-0)3
MA	204	Calculus IV	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		Total hours	(18-3)19

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-3)4
CN	303	Chemical Engineering Principles I	(3-0)3
CN	311	Chemical Engineering Thermodynamics	(3-0)3
CN	315	Chemical Engineering Laboratory II	(0-3)1
		General Elective	(3-0)3
		Technical Elective*	(3-0)3
		Total hours	(15-6)17

*ROTC students will substitute AS 301

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
CN	304	Chemical Engineering Principles II	(3-0)3
CN	314	Process Dynamics and Control	(3-0)3
CN	316	Chemical Engineering Laboratory III	(0-3)1
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(15-6)17

SENIOR YEAR

First Semester

CN	403	Reactor Design and Kinetics	(3-0)3
CN	407	Engineering Analysis of Chemical Processes	(3-0)3
		Technical Elective	(3-0)3
		Technical Elective*	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-0)15

*ROTC students will substitute AS 401

Second Semester

CN	408	Engineering Materials	(3-0)3
CN	410	Process Analysis and Plant Design	(3-0)3
CN	416	Profession Orientation	(2-0)0
EE	353	Electrical Controls and Power Circuits	(3-0)3
		General Elective	(3-0)3
		General Elective or Technical Elective	(3-0)3
		Total hours	(17-0)15

CHEMISTRY

The curriculum in Chemistry is designed to provide both a thorough knowledge of the basic principles and techniques of chemistry and advanced instruction in its most important branches. It includes essential subjects in physics and mathematics, and through an elective system it permits the student to broaden his education by a choice of related science and engineering subjects. The curriculum includes a minimum of eighteen credits in the humanities and social sciences in order that a suitable cultural background may be acquired to meet the exacting requirements for growth and advancement in the present-day professional life of the chemist.

A graduate of the Chemistry curriculum may select any of several avenues in developing his professional life. Those wishing to engage in teaching and research at the college or university level or research in industry are advised to continue study for an advanced degree. Those wishing to enter directly into industry after graduation, however, may consider such fields as research and development, technical service, production, and sales.

The curriculum has been approved by the Committee on Professional Training of the American Chemical Society, and required subjects and credits are designed to meet the latest recommended standards. Students satisfactorily completing such an approved program are registered with the ACS and are eligible for full membership in the society after two years.

Admission to the sophomore year in the chemistry curriculum is contingent upon the student's receiving a minimum grade of C- in each of the two semesters of Chemical Principles (CH 001-002) and Chemical Principles Laboratory (CH 003-004). The following curriculum is effective for the class of 1972.

SOPHOMORE YEAR

First Semester

CH	207	Inorganic Chemistry	(3-4)4
CH	221	Organic Chemistry	(3-4)4
MA	203	Calculus III	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(16-10)18

Second Semester

CH	210	Analytical Chemistry I	(3-4)4
CH	222	Organic Chemistry	(3-4)4
CH	232	Physical Chemistry	(3-3)4
MA	204	Calculus IV	(3-0)3
		Total hours	(12-11)15

JUNIOR YEAR

First Semester

CH	311	Analytical Chemistry II	(2-4)3
CH	333	Physical Chemistry	(3-3)4
LL	261	Elementary Scientific German	(3-0)3
		Two General Electives	(6-0)6
		Total hours	(14-7)16

Second Semester

CH	442	Advanced Inorganic Chemistry	(3-0)3
LL	262	Elementary Scientific German	(3-0)3
		Chemistry Elective	3 or 4
		Two General Electives	(6-0)6
		Total credit hours	15 or 16

SENIOR YEAR

First Semester

Chemistry Elective	3 or 4
Two Technical Electives	6
Two General Electives	(6-0)6
Total credit hours	15 or 16

Second Semester

Chemistry Elective	3 or 4
Two Technical Electives	6
Two General Electives	(6-0)6
Total credit hours	15 or 16

The Technical Electives in the Junior and Senior year must include chemistry subjects which will provide a minimum of 60 contact hours of laboratory instruction. Recommended laboratory electives include CH 321, CH 342, CH 403-404, CH 407-408 and CH 481-482. If CH 407-408 is elected both semesters must be taken, and one additional laboratory subject must also be taken to provide an approved program.

CIVIL ENGINEERING

Civil Engineering is that branch of engineering charged with the planning, design, construction and operation of works vital to man's activities in his relation to the environment. The concerns of the Civil Engineer include the gathering and proccessing of environmental information; avenues of transportation; facilities and structures to accommodate domestic, business, industrial, scientific, and recreational pursuits; the control and management of the forces of nature as such affect the environment; the treatment and disposal of solid, liquid and aerial wastes; and the adaptation of materials, natural or manmade, to the works under his control.

Because of the broad range of the civil engineer's activities, this curriculum is first based on a breadth of scientific and engineering principles. Such fundamentals are then expanded into specialized subjects to provide a comprehensive and basic training in the responsibilities of the Civil Engineer.

Graduates of Civil Engineering are prepared to apply their training to highways, railroads, airports, pipelines and waterways; bridges, dams, canals and levees; filtration plants and distribution systems for municipal and industrial water supplies along with sewage and waste treatment plants to protect health. Also in their province are Civil Engineering aspects of high-rise buildings, power plants, industrial, military and space facilities. After advanced training, the areas of research and teaching are open to them.

SOPHOMORE YEAR

First Semester

CE	201	Surveying I		(3-4)4
EC	201	Economics I		(3-0)3
MA	203	Calculus III		(3-0)3
ME	211	Mechanics I		(3-0)3
PH	201	Physics		(4-2)4
			Total hours	(16-6)17

Second Semester

CE	202	Surveying II		(3-4)4
EC	202	Economics II		(3-0)3
MA	204	Calculus IV		(3-0)3
ME	220	Mechanics of Materials I		(3-0)3
PH	202	Physics		(4-2)4
			Total hours	(16-6)17

JUNIOR YEAR

First Semester

CE	341	Transportation	(3-3)4
EE	211	Fundamentals of Electricity	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	309	Dynamics I	(3-0)3
		Technical Elective*	(3-0)3
		General Elective	(3-0)3
		Total hours	(18-3)19

*ROTC students will substitute AS 301

Second Semester

CE	312	Structures I	(3-0)3
CE	322	Hydraulics	(4-0)4
EE	212	Introductory Electronics	(3-0)3
EE	214	Electrical Machinery Laboratory	(0-3)1
MA	362	Numerical Analysis	(3-0)3
ME	304	Materials Laboratory	(0-3)1
		General Elective	(3-0)3
		Total hours	(16-6)18

SENIOR YEAR

First Semester

CE	411	Structures II	(3-3)4
CE	413	Concrete	(3-3)4
CE	421	Hydrology	(3-3)4
CE	431	Soil Mechanics I	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-9)18

Second Semester

CE	412	Structures III	(3-3)4
CE	432	Soil Mechanics II	(3-3)4
EC	414	Engineering Economy	(3-0)3
		Technical Elective*	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-6)17

*ROTC students will substitute AS 402

CIVIL ENGINEERING TECHNOLOGY

The following curriculum leading to the degree of Bachelor of Science in Engineering Technology in the field of Civil Engineering Technology is available only to employees of the Commonwealth of Massachusetts as an In-Service Training Program. For regulations concerning this program and for subjects required prior to the following curriculum, consult the Catalogue of the Division of Evening Studies of the Lowell Technological Institute.

JUNIOR YEAR

Second Semester

CE	961	Advanced Surveying	(2-1)2
CE	971	Structures	(2-1)2
DP	931	Scientific Computer Programming — FORTRAN	(3-0)3
LL	962	American Literature	(3-0)3
PH	942	Physics	(3-2)4
		General Elective	(3-0)3
		Total hours	(16-4)17

SENIOR YEAR

First Semester

CE	982	Hydrology	(3-3)4
CE	991	Concrete Analysis and Design	(3-3)4
CE	995	Engineering Laboratory	(0-3)1
EE	975	Basic Electricity	(3-3)4
		General Elective	(3-0)3
		Total hours	(12-12)16

Second Semester

CE	981	Structural Analysis and Design	(3-3)4
CE	992	Soil Mechanics	(3-3)4
CE	996	Engineering Problems	(1-2)1
EE	978	Basic Electronics	(3-0)3
		General Elective	(3-0)3
		Total hours	(13-8)15

ELECTRICAL ENGINEERING

The objective of the curriculum in Electrical Engineering is to provide the student with a sound foundation for a professional career in electrical engineering.

Students are given a thorough grounding in electrical science and engineering together with an intensive training in mathematics. The techniques of experimental science and technology are emphasized by investigative work in the laboratory and lecture-demonstrations in the classroom.

A significant portion of the curriculum is devoted to studies in the humanities and social sciences, with considerable choice of subjects allowed. These subjects form an important part of the program, since they broaden the student's outlook. They also serve to focus attention on the importance of non-technical knowledge in determining the student's ultimate level of responsibility in professional life.

A freshman seeking admission to the sophomore year of Electrical Engineering should have achieved a cumulative rating of 2.00 by the end of his freshman year. Students with less than a 2.00 cumulative rating must submit a written petition requesting admission to the department at least one week prior to the date of registration. Only students who appear to have a reasonable probability of successfully completing the curriculum will be permitted to register as sophomores in the department.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	201	Introductory Circuit Theory	(4-0)4
EE	207	Basic Electrical Engineering Laboratory	(1-3)2
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)16

Second Semester

EC	202	Economics II	(3-0)3
EE	202	Introductory Circuit Theory	(4-0)4
EE	208	Basic Electrical Engineering Laboratory	(1-3)2
MA	204	Calculus IV	(3-0)3
ME	212	Mechanics and Properties of Matter	(4-0)4
		Total hours	(15-3)16

JUNIOR YEAR

First Semester

EE	311	Electronics Laboratory	(1-3)2
EE	315	Network Analysis	(4-0)4
		or	
EE	318	Digital Computation in Electrical Engineering	(3-3)4
EE	319	Electronics I	(4-0)4
MA	313	Engineering Mathematics	(4-0)4
		General Elective	(3-0)3
		Total credit hours	17

Second Semester

EE	306	Electromagnetic Theory	(4-0)4
EE	312	Electronics Laboratory	(1-3)2
EE	318	Digital Computation in Electrical Engineering	(3-3)4
		or	
EE	315	Network Analysis	(4-0)4
EE	320	Electronics II	(4-0)4
		General Elective	(3-0)3
		Total credit hours	17

SENIOR YEAR

First Semester

EE	413	Linear Feedback Systems	(3-0)3
ME	347	Elements of Thermodynamics and Heat Transfer	(3-0)3
		General Elective	(3-0)3
		EE Technical Elective	3
		Free Elective or AS 401	3
		Total credit hours	15

Second Semester

EE	454	Electromechanics	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
		Free Elective*	3
		Free Elective or AS 402	3
		Total credit hours	15

*ROTC students must choose a general elective.

INDUSTRIAL MANAGEMENT

Recent technological developments in industry have necessitated the acquisition of special skills on the part of business management. Accordingly, the Industrial Management curriculum is designed to provide a student with a sound foundation in the pure sciences and mathematics, in the humanities, and in the social sciences. In addition, the core subjects of management — accounting, finance, marketing and production — are required. All students also take a selection of engineering and management courses to prepare them to handle the tasks they will have in industry after graduation. Some specialization is provided in the junior and senior years under guidance of a Faculty Advisor.

SOPHOMORE YEAR

First Semester

BA	141	Accounting I	(3-0)3
BA	321	Marketing Principles	(3-0)3
EC	211	Economic Statistics I	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
PH	101	Physics	(4-1)4
		LL Elective	(3-0)3
		Total hours	(17-4)18

Second Semester

BA	142	Accounting II	(3-0)3
BA	324	Industrial Marketing	(3-0)3
EC	212	Economic Statistics II	(3-0)3
PH	102	Physics	(4-2)4
		LL Elective	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

BA	331	Business Finance	(3-0)3
BA	371	Production Management I	(3-0)3
IM	351	Motion and Time Study	(0-2)1
ME	315	Applied Mechanics	(3-0)3
ME	377	Elements of Materials Science	(2-0)2
PH	201	Physics	(4-2)4
		Concentration Elective*	3
		Total credit hours	19

Second Semester

BA	332	Money and Banking	(3-0)3
BA	344	Cost Accounting**	
		or	(3-0)3
BA	346	Managerial Accounting	
BA	372	Production Management II	(3-0)3
EC	302	Labor Economics	(3-0)3
ME	372	Strength of Materials	(3-0)3
		Concentration Elective	3
		Total credit hours	18

*Concentration areas are provided as follows. The sequence selected by the student must be followed through his senior year unless a waiver is granted by his Faculty Advisor and Department Head.

(A) Air Science: student takes AS 301, 302, 401, 402.

(B) Economics: student takes EC 303, 304 and two other EC courses.

(C) Accounting: student takes BA 241, 242, 341, 342.

(D) Finance: student takes 12 hours in agreement with his Faculty Advisor.

(E) Marketing: student takes BA 326, 423 and two other marketing courses.

(F) Mathematics: student takes MA 203, 204 and two other MA courses.

**Accounting majors take BA 344.

SENIOR YEAR

First Semester

BA	451	Personnel Management	(3-0)3
EE	351	Industrial Electronics	(3-0)3
IM	371	Operations Research	(3-0)3
IM	483	Statistical Quality Control	(3-0)3
		Management Elective*	(3-0)3
		Concentration Elective	3
		Total credit hours	18

Second Semester

BA	362	Business Law	(3-0)3
EC	402	Government and Business	(3-0)3
EC	412	Managerial Economics	(3-0)3
ME	344	Heat and Power	(3-0)3
		Management Elective*	(3-0)3
		Concentration Elective	3
		Total credit hours	18

*The student may select a subject bearing a BA, EC, or IM designation, or SS303 or SS305. Accounting majors must take BA444 in first semester.

MATHEMATICS

The objectives of the Mathematics program are twofold: (1) to provide the student with the opportunity to become acquainted with the major areas of modern mathematics — algebra, analysis, geometry and applied mathematics, including computing science and numerical analysis, and (2) to enable him to achieve a certain mastery in depth of one or more of these areas.

The approaches to these objectives are also twofold, viz., by way of course work and supervised project activity. In order to achieve breadth, each of the major areas mentioned above is represented by at least one required three-hour subject. A deeper study of one or more areas is provided by the student's elective program, subject to the approval of his departmental advisor.

The purpose of the project work is to enable the student to "read, write, and speak" mathematics via the reading of simple journal articles, the preparation of short papers, and oral presentations. This aspect of the program is regarded as at least as important as the formal course work. Participation in a working seminar is required of all mathematics majors during the senior year.

As designed, the curriculum exceeds the minimum recommendations of the Committee on Undergraduate Programs in Mathematics of the Mathematical Association of America for college mathematics programs. It provides a strong basis both for subsequent graduate study and for employment in the several fields of teaching and industry.

A freshman seeking admission to the sophomore year of Mathematics should have achieved a cumulative rating of 2.00 by the end of his freshman year. Students with less than a 2.00 cumulative rating must submit a written petition requesting admission to the department at least one week prior to the date of registration. Only students who appear to have a reasonable probability of successfully completing the curriculum will be permitted to register as sophomores in the department.

SOPHOMORE YEAR

First Semester

MA	203	Calculus III	(3-0)3
MA	221	Linear Algebra	(3-0)3
PH	201	Physics	(4-2)4
		Approved Modern Foreign Language	(3-0)3
		General Elective	(3-0)3
		Total hours	(16-2)16

Second Semester

MA	204	Calculus IV	(3-0)3
MA	222	Linear Algebra	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
		Approved Modern Foreign Language	(3-0)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	18

JUNIOR YEAR

First Semester

MA	307	Advanced Calculus	(3-0)3
MA	321	Modern Algebra	(3-0)3
		Applied Mathematics Elective*	(3-0)3
		Technical or General Elective	3
		General Elective	(3-0)3
		Total credit hours	15

*To be selected from an approved departmental list.

Second Semester

MA	308	Advanced Calculus	(3-0)3
MA	334	Projective Geometry	(3-0)3
		Mathematics Elective	(3-0)3
		Technical or General Elective	3
		General Elective	(3-0)3
		Total credit hours	15

SENIOR YEAR

First Semester

MA	411	Complex Variables I	(3-0)3
MA	431	Topology I	(3-0)3
MA	495	Mathematics Seminar	(1-0)1
		Mathematics Elective	(3-0)3
		Technical or General Elective	3
		General Elective	(3-0)3
		Total credit hours	16

Second Semester

MA	496	Mathematics Seminar	(1-0)1
		Two Mathematics Electives	6
		Technical of General Elective	3
		General Elective	(3-0)3
		Total credit hours	13

MECHANICAL ENGINEERING

Mechanical Engineering is a diversified professional activity. The mechanical engineer is called upon to develop new methods of energy production and conversion, transportation, manufacture, and fabrication.

Because of the diversification of mechanical engineering, it is not possible for a student to master the entire field during a four year program. The objective of this curriculum is to provide a broad fundamental base from which the graduate can go on to develop his skills by either entering general engineering practice or pursuing an advanced engineering degree.

The curriculum is designed to achieve this objective by means of a three phase program.

The first phase consists of acquiring a background in humanistic-social studies, and the basic sciences. The purpose of the first phase is to broaden the student's outlook and provide a firm understanding of fundamentals, develop analytical techniques, and to prepare for specific technical subjects.

The second phase consists of acquiring a knowledge in a coherent area of engineering science. The purpose of this phase is to form the link between the basic sciences and engineering, and to introduce the methodology of engineering analysis, design and synthesis. Three areas of engineering science have been selected for this phase; namely, applied mechanics (statics, dynamics and mechanics of materials), thermaltransport (thermodynamics, fluid mechanics and heat transfer), and automatic controls (electricity, electronics, measurements, and control systems).

In the final phase of the curriculum, advanced problems and topics are considered in engineering design. The purpose of the design activity is to develop skill in the use of science and creativity to solve engineering problems and thus requires the utilization of the first two phases.

A variety of laboratory work is included in the curriculum in order to demonstrate the use of the experimental method in the solution of engineering problems.

To permit a degree of specialization, four technical electives are provided in the senior year. A staff advisor system is used in order to aid the student in selecting technical electives so that the subjects will be consistent with the future career plans of the student.

This curriculum is accredited by the Engineers' Council for Professional Development.

A freshman seeking admission to the sophomore year of Mechanical Engineering should have achieved a cumulative

rating of 2.00 by the end of his freshman year. Students with less than a 2.00 cumulative rating must submit a written petition requesting admission to the department at least one week prior to the date of registration. Only students who appear to have a reasonable probability of successfully completing the curriculum will be permitted to register as sophomores in the department.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
ME	205	Introduction to Mechanical Design	(2-3)3
ME	211	Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	220	Mechanics of Materials I	(3-0)3
ME	296	Materials Science	(3-0)3
		General Elective	(3-0)3
		Total hours	(18-0)18

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
ME	301	Mechanical Engineering Laboratory I	(0-3)1
ME	309	Dynamics I	(3-0)3
ME	341	Thermodynamics I	(3-0)3
ME	351	Measurement	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-3)16

Second Semester

MA	302	Advanced Calculus for Applications	(3-0)3
ME	314	Mechanical Engineering Laboratory II	(0-3)1
ME	320	Machine Design I	(2-3)3
ME	382	Fluid Mechanics I	(3-0)3
		General Elective	(3-0)3
		Technical Elective*	(3-0)3
		Total hours	(14-6)16

*ROTC students will substitute AS302

SENIOR YEAR

First Semester

EC	201	Economics I	(3-0)3
ME	415	Mechanical Engineering Laboratory III	(0-3)1
ME	417	Dynamics II	(3-0)3
ME	443	Heat Transfer	(3-0)3
ME	497	Automatic Control Systems I	(3-0)3
		Technical Elective*	3
		Total credit hours	16

*ROTC students will substitute AS 401

TECHNICAL ELECTIVES

Group A

ME	441	Statistical Thermodynamics	(3-0)3
ME	473	Mechanics of Materials II	(3-0)3

Group B

ME	419	Nondestructive Evaluation Techniques	(3-0)3
ME	475	Physical Metallurgy	(3-0)3

Second Semester

EC	202	Economics II	(3-0)3
ME	416	Senior Project	(0-3)1
ME	430	Design of Mechanical Systems	
		or	(3-0)3
ME	442	Design of Thermal Systems	
		Technical Elective*	3
		Technical Elective	3
		(ROTC students take ME-342)	
		Technical Elective	3
		Total credit hours	16

*ROTC students will substitute AS 402

TECHNICAL ELECTIVES

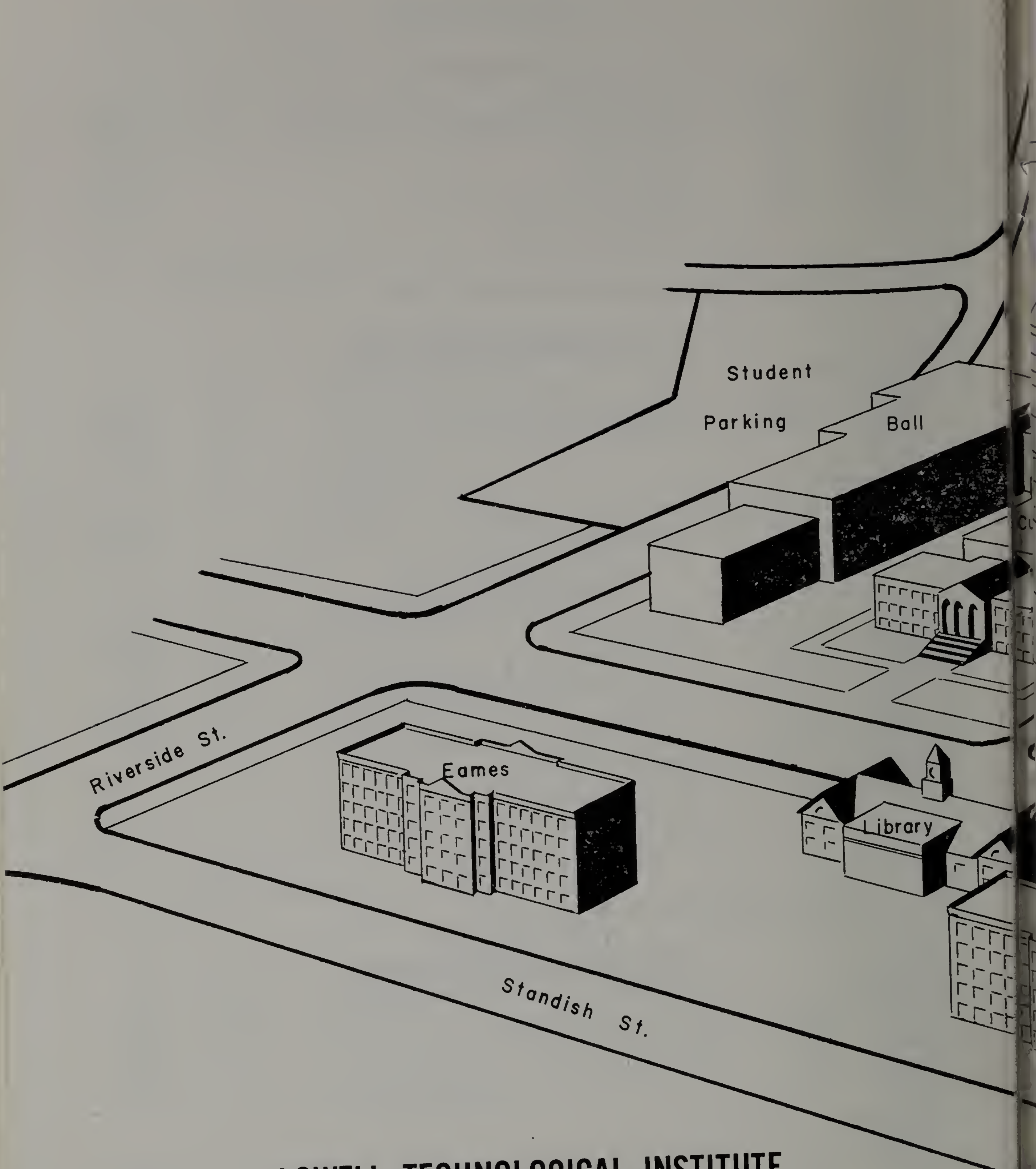
Group A

ME	462	Engineering Analysis	(3-0)3
ME	482	Fluid Mechanics II	(3-0)3
ME	498	Automatic Control Systems II	(3-0)3

Group B

ME	422	Machine Design II	(2-3)3
ME	428	Kinematic Mechanism Synthesis	(3-0)3
ME	446	Energy Conversion	(3-0)3
ME	452	Applications of Numerical Analysis	(3-0)3
ME	468	Fluid Machinery	(3-0)3
ME	472	Experimental Stress Analysis	(2-3)3
ME	488	Environmental Conditioning	(3-0)3

A minimum of one half of a student's total number of technical electives must come from Group A.



LOWELL TECHNOLOGICAL INSTITUTE

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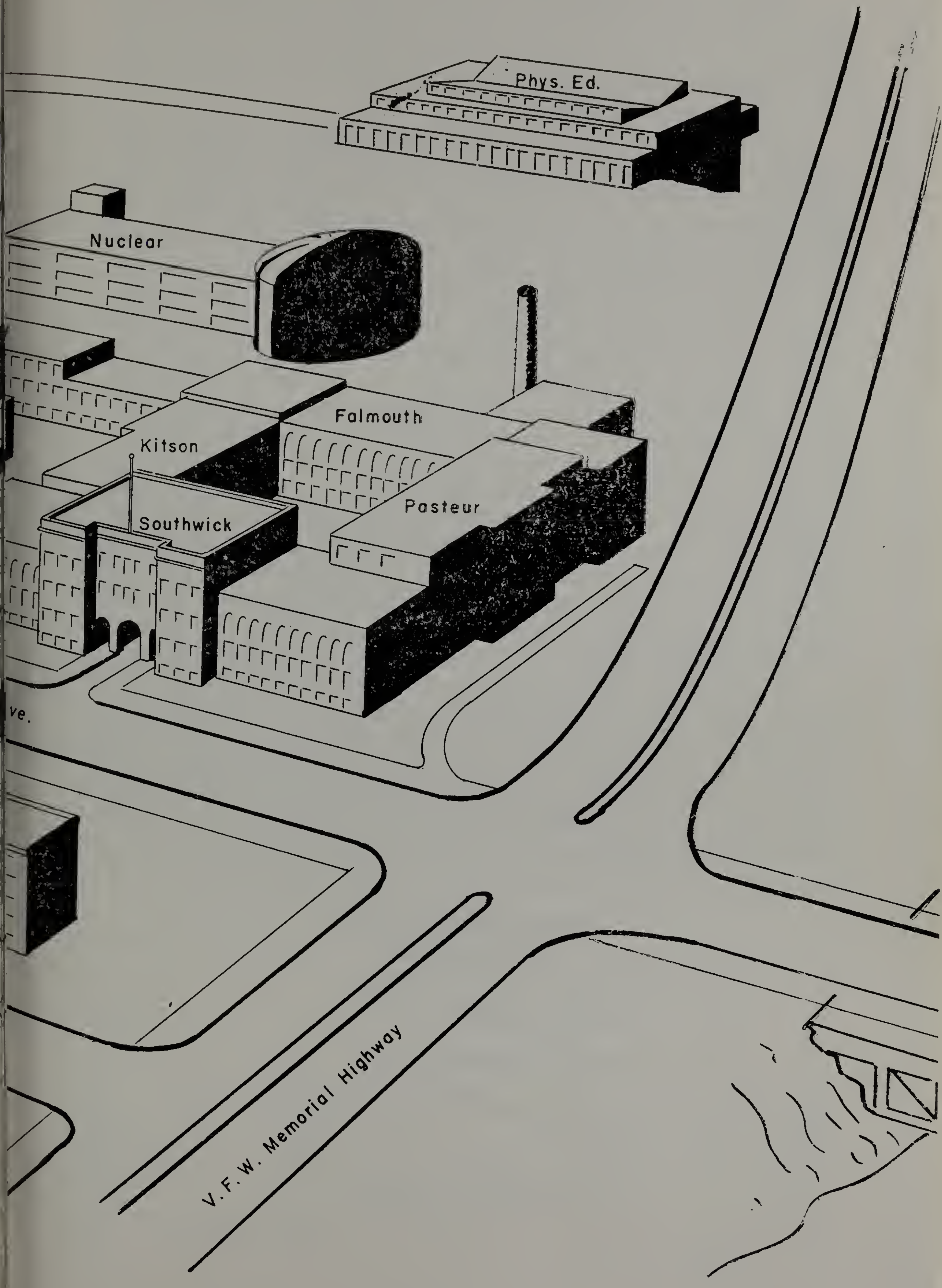
BOOKSTORE: THIRD FLOOR, SOUTHWICK HALL.

DIVISION OF EVENING STUDIES OFFICE: BASEMENT, CUMNOCK HALL.



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METEOROLOGY

Meteorology is the study of the physical and chemical processes that occur in the atmosphere and between the atmosphere and the earth's surface. The advent of space exploration has broadened the scope of meteorology to include atmospheres of the other planets.

The work of meteorologists is concentrated on the effort to understand the physical causes of weather and climate and to apply the knowledge gained to the solution of practical problems ranging from the forecasting of tomorrow's weather for the general public to the analysis of the influence of weather and climate on particular operations in agriculture, engineering, industry and commerce, national defense and public health. Meteorologists are employed in these capacities by the agencies of the Environmental Science Services Administration, especially the Weather Bureau, by agencies of the Defense Department and by commercial aviation companies and private consulting firms. Meteorological research conducted by agencies of the U. S. Government, universities and private research companies is becoming increasingly important as a field of employment. Although graduate training is essential for advancement in this field, the U. S. Government and most private employers provide opportunities for individuals to acquire this training. The bachelor of science curriculum prepares the student for a career as a meteorologist in government or private industry and provides a sound foundation for graduate study.

A freshman seeking admission to the sophomore year of Meteorology should have achieved a cumulative rating of 2.00 by the end of his freshman year. Students with less than a 2.00 cumulative rating must submit a written petition requesting admission to the department at least one week prior to the date of registration. Only students who appear to have a reasonable probability of successfully completing the curriculum will be permitted to register as sophomores in the department.

SOPHOMORE YEAR
First Semester

LL	261	Elementary Technical German	
		or	
LL	263	Elementary French	(3-0)3
		or	
LL	265	Elementary Russian	
		or	
LL	267	Elementary Spanish	
MA	203	Calculus III	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		General or Technical Elective	3
		Total credit hours	16

Second Semester

LL	262	Elementary Technical German	
		or	
LL	264	Elementary French	
		or	(3-0)3
LL	266	Elementary Russian	
		or	
LL	268	Elementary Spanish	
MA	204	Calculus IV	(3-0)3
MY	203	Elementary Meteorology	(3-0)3
PH	202	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

MA	360	Digital Computer Programming	(3-0)3
MA	383	Statistical Methods	(3-0)3
MY	301	Atmospheric Dynamics	(3-0)3
MY	307	Tropical Meteorology	(3-0)3
		Technical or General Elective	3
		Total credit hours	15

Second Semester

MA	362	Numerical Analysis	(3-0)3
MY	302	Atmospheric Dynamics	(3-0)3
MY	308	Synoptic Meteorology	(2-3)3
		General and Technical Electives	6
		Total credit hours	15

SENIOR YEAR

First Semester

MY	403	Physical Meteorology	(3-0)3
MY	405	Individual Studies	(1-0)1
MY	411	Oceanography	(2-0)2
MY	421	Analysis and Forecasting	(1-6)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	15

Second Semester

MY	406	Individual Studies	(1-0)1
MY	412	Oceanography	(2-0)2
MY	414	Mathematical Methods in Meteorology	(3-0)3
MY	422	Analysis and Forecasting	(1-6)3
		General Elective	(3-0)3
		Technical Elective	3
		Total credit hours	15

NUCLEAR ENGINEERING

The Nuclear Engineering course was the first to be offered in a publicly supported institution in New England. The curriculum provides a broad engineering education which is supplemented with special training in the nuclear field. The student is prepared for resonsible positions in industry or for study at the graduate level.

A freshman seeking admission to the sophomore year of Nuclear Engineering should have achieved a cumulative rating of 2.00 by the end of his freshman year. Students with less than a 2.00 cumulative rating must submit a written petition requesting admission to the department at least one week prior to the date of registration. Only students who appear to have a reasonable probability of successfully completing the curriculum will be permitted to register as sophomores in the department.

Six general electives are required and can be selected from the elective system with the exception of LL 261-262, LL 265-266, LL 365-366 and EC 301 thru EC 414.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
NU	201	Introduction to Nuclear Engineering	(3-0)3
PH	201	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

Second Semester

EE		Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
NU	202	Introduction to Nuclear Engineering	(3-0)3
PH	202	Physics	(4-2)4
		General Elective	(3-0)3
		Total hours	(16-2)16

JUNIOR YEAR

First Semester

MA	301	Advanced Calculus for Applications	(3-0)3
ME	341	Thermodynamics 1	(3-0)3
NU	305	Nuclear Instrumentation	(2-4)4
PH	363	Introductory Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(14-4)16

Second Semester

CH	481	Radiochemistry	(2-3)3
MA	302	Advanced Calculus for Applications	(3-0)3
NU	306	Nuclear Instrumentation	(2-4)4
PH	366	Intermediate Nuclear Physics	(3-0)3
		General Elective	(3-0)3
		Total hours	(13-7)16

SENIOR YEAR

First Semester

ME	382	Fluid Mechanics I	(3-0)3
NU	405	Nuclear Reactor Engineering	(3-0)3
NU	493	Advanced Nuclear Laboratory	(0-6)3
		Technical Elective*	(3-0)3
		General Elective	(3-0)3
		Total hours	(12-6)15

Second Semester

ME	443	Heat Transfer	(3-0)3
NU	406	Nuclear Reactor Engineering	(3-0)3
NU	494	Advanced Nuclear Laboratory	(0-6)3
		General Elective	(3-0)3
		Technical Elective*	(3-0)3
		Total hours	(12-6)15

APPROVED TECHNICAL ELECTIVES

EE	446	Analog and Digital Devices & Technigues	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
RS	422	Environmental Radiation and Nuclear Site Criteria	(3-0)3
NU	495	Special Nuclear Problems (Permission of Head of Department and Instructor)	(3-0)3

*ROTC students will substitute AS courses.

PAPER ENGINEERING

The paper industry is the fifth largest industry in the United States, and by virtue of its broad spectrum of products, provides both growth and stability. The products of the paper and allied industries are integral with every aspect of human life and endeavor.

The increasing complexity of pulp and paper operations, increasing demands on the paper converting industry (which involve plastics, chemicals, metals and other materials), and the need for automation, have created an intense and growing demand for well-trained engineers in all aspects of the business. These engineers must not only have a fundamental scientific training, but must have a broad background of practical problem solving.

The Paper Engineering curriculum is basically chemical engineering with a minor in paper engineering. In fact, the two degrees may be obtained by taking a couple of extra courses in the senior year. Emphasis is placed on an engineering analysis of the paper industry, its production methods, fundamental properties of its raw materials and the unit operations involved in manufacture of paper and allied products. Graduates of Paper Engineering may go either directly into industry or continue on to graduate studies. In the paper industry, they may find themselves in positions in research and development, production, sales or marketing, and frequently in management, in a wide variety of activities.

Paper Engineers who maintain a 2.00 cumulative rating are eligible for scholarships carrying a $500 annual stipend.

SOPHOMORE YEAR

First Semester

CH	223	Introductory Organic Chemistry	(3-3)4
CN	203	Introduction to Chemical Engineering	(3-0)3
CN	205	Chemical Engineering Laboratory I	(0-3)1
EC	201	Economics I	(3-0)3
MA	203	Calculus III	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
		Total hours	(16-9)19

Second Semester

CH	224	Introductory Organic Chemistry	(3-3)4
CN	204	Chemical Engineering Calculations	(3-0)3
EC	202	Economics II	(3-0)3
MA	204	Calculus IV	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
		Total hours	(18-3)19

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-3)4
CN	303	Chemical Engineering Principles I	(3-0)3
CN	311	Chemical Engineering Thermodynamics	(3-0)3
CN	315	Chemical Engineering Laboratory II	(0-3)1
PA	301	Engineering Analysis of Pulp Systems	(3-3)4
		Technical Elective*	(3-0)3
		Total hours	(15-9)18

*ROTC students will substitute AS 301

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
CN	304	Chemical Engineering Principles II	(3-0)3
CN	314	Process Dynamics and Control	(3-0)3
CN	316	Chemical Engineering Laboratory III	(0-3)1
PA	302	Engineering Analysis of Paper Systems	(3-3)4
		General Elective	(3-0)3
		Total hours	(15-9)18

SENIOR YEAR

First Semester

PA	403	Engineering Analysis of Converting	(3-0)3
PA	405	Paper Converting Laboratory I	(0-3)1
PA	407	Paper Problems	(2-0)2
		General Elective	(3-0)3
		General Elective	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(14-3)15

Second Semester

EE	353	Electrical Controls and Power Circuits	(3-0)3
PA	408	Paper Converting Laboratory II	(0-3)1
PA	410	Analysis of Paper Processing	(2-0)2
CN	416	Profession Orientation	(2-0)0
		General Elective	(3-0)3
		General Elective or Technical Elective*	(3-0)3
		Technical Elective	(3-0)3
		Total hours	(16-3)15

*ROTC students will substitute AS 402

PHYSICS

This program was developed to meet the demands of industry, education, and government for research personnel and teachers with an intensive training in physics. It should be contemplated only by those with superior competence in mathematics.

A freshman seeking admission to the sophomore year of Physics should have achieved a cumulative rating of 2.00 by the end of his freshman year. Students with less than a 2.00 cumulative rating must submit a written petition requesting admission to the department at least one week prior to the date of registration. In freshman physics and mathematics subjects only, a student will be expected to have a cumulative average of 2.50 and no grades below C-. A student in the program is expected to do much better than this minimum.

SOPHOMORE YEAR

First Semester

PH	207	Mathematical Techniques of Physics I	(4-0)4
PH	209	Physics	(4-0)4
PH	293	Experimental Physics	(2-6)4
		General or Technical Elective	(3-0)3
		Total hours	(13-6)15

Second Semester

PH	208	Mathematical Techniques of Physics II	(4-0)4
PH	210	Physics	(4-0)4
PH	294	Experimental Physics	(2-6)4
		General or Technical Elective	(3-0)3
		Total hours	(13-6)15

JUNIOR YEAR

First Semester

PH	311	Intermediate Mechanics	(3-0)3
PH	335	Modern Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
		General or Technical Elective*	(3-0)3
		General or Technical Elective**	3
		Total credit hours	15

*ROTC students will substitute AS 301.

**A student can elect to take Advanced Laboratory PH 393 at this stage.

Second Semester

PH	312	Intermediate Mechanics	(3-0)3
PH	336	Modern Physics	(3-0)3
PH	353	Electromagnetic Theory	(3-0)3
		General or Technical Elective*	(3-0)3
		General or Technical Elective**	3
		Total credit hours	15

*ROTC students will substitute AS 302.

**A student can elect to take Advanced Laboratory PH 394 at this stage.

SENIOR YEAR

First Semester

PH	423	Thermodynamics	(3-0)3
		Two General or Technical Electives	(6-0)6
		General or Technical Elective*	(3-0)3
		General or Technical Elective**	3
		Total credit hours	15

*ROTC students will substitute AS 401.

**A student can elect to take Advanced Laboratory PH 393 at this stage.

Second Semester

PH	424	Introduction to Statistical Mechanics	(3-0)3
		Two Technical Electives	(6-0)6
		General or Technical Elective*	(3-0)3
		General or Technical Elective**	3
		Total credit hours	15

*ROTC students will substitute AS 402.

**A student can elect to take Advanced Laboratory PH 394 at this stage.

TECHNICAL ELECTIVES

PH	441-442	Introduction to Relativity and Quantum Mechanics	(3-0)(3-0)6
PH	461-462	Nuclear Physics	(3-0)(3-0)6
PH	471-472	Solid State Physics	(3-0)(3-0)6
PH	393-394	Advanced Laboratory	(1-6)(1-6)6
PH	495-496	Special Research Problems	(3-0)(3-0)6
PH	505-506	Mathematical Methods of Physics	(3-0)(3-0)6
PH	511-512	Classical Mechanics	(3-0)(3-0)6
MA	411	Complex Variables I	(3-0)3
MA	434	Matrix Algebra	(3-0)3
MA	484	Probabilities	(3-0)3
MA	542	Fourier Series and Boundary Value Problems	(3-0)3
MA	575	Operational Mathematics	(3-0)3

All physics majors must take no less than six and no more than ten General Electives. In addition to the approved technical electives, any course offered by the Institute, and which is approved by the Student Advisor and the Department Head, may be taken as technical elective.

All students must elect one year of either PH 393-394, Advanced Laboratory, or PH 505-506, Mathematical Methods of Physics.

PLASTICS TECHNOLOGY

The objective of this curriculum is to prepare the graduate for a professional career in the field of high polymers. In order that he may cope effectively with the many diversified problems confronting the expanding plastics industry, strong emphasis is placed on the study of engineering and chemical principles involved in design, processing, and fabrication of polymeric materials.

However, the close relationship existing between the physical behavior and chemical structure of polymers make it mandatory to include a number of chemistry courses not traditionally found in most engineering curricula.

Subjects dealing with polymer properties, statistics, and quality control augment the basic courses in mathematics, sciences, and engineering and plastics technology to round out a well-balanced program.

Students electing Plastics Technology are privileged to become affiliated with the first student chapter of the international Society of Plastics Engineers, an opportunity which affords every student member an early and rewarding professional association.

SOPHOMORE YEAR

First Semester

CH	223	Introductory Organic Chemistry	(3-3)4
CH	211	Quantitative Analysis	(3-4)4
		or	
CH	205	Qualitative Analysis	(3-0)3
MA	203	Calculus III	(3-0)3
PH	201	Physics III	(4-2)4
PL	201	Introduction to Polymeric Materials	(2-0)2
		Total hours	(15-5)16 or (15-9)17

Second Semester

CH	224	Introductory Organic Chemistry	(3-3)4
CH	205	Qualitative Analysis	(3-0)3
		or	
CH	211	Quantitative Analysis	(3-4)4
EE	353	Electrical Controls and Power Circuits	(3-0)3
LL	210	Technical and Scientific Communication	(3-0)3
MA	383	Statistical Methods	(3-0)3
PL	202	Introduction to Polymeric Materials	(2-0)2
		Total hours	(17-3)18 or (17-7)19

JUNIOR YEAR

First Semester

CH	335	Principles of Physical Chemistry	(3-3)4
EC	201	Economics I*	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
ME	271	Machine Tool Laboratory	(1-3)2
ME	373	Plastics Mold and Die Design	(2-2)3
PL	301	Plastics Technology I	(2-2)3
		Total hours	(14-10)18

*ROTC students will substitute AS 301

Second Semester

CH	336	Principles of Physical Chemistry	(3-3)4
EC	202	Economics II*	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
ME	296	Materials Science	(3-0)3
ME	376	Plastics Mold Design and Construction	(0-3)1
PL	302	Plastics Technology II	(2-2)3
		Total hours	(14-8)17

*ROTC students will substitute AS 302

SENIOR YEAR

First Semester

CH	403	Chemistry of High Polymers	(3-4)4
ME	493	Industrial Instrumentation	(2-0)2
PL	401	Plastics Technology III	(2-2)3
PL	403	Properties of Polymers	(2-2)3
PL	411	Plastics Seminar	(1-0)1
		Elective	3
		Total credit hours	16

Second Semester

CH	404	Chemistry of High Polymers	(3-4)4
PL	402	Plastics Technology IV	(2-2)3
PL	404	Properties of Polymers	(2-2)3
PL	412	Plastics Seminar	(1-0)1
		Two Electives	6
		Total credit hours	17

Suggested Electives

CH	423-424	Advanced Organic Chemistry	(3-0)(3-0)6
IM	483	Statistical Quality Control	(3-0)3
LL	261-262	Elementary Scientific German	(3-0)(3-0)6
MA	204	Calculus IV	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	384	Fluid Mechanics	(3-0)3
PL	406	Polymer Structure	(3-0)3
PL	407	Plastics Industry Organization	(3-0)3
PL	409-410	Senior Research in Plastics	(1-6)(1-6)6

TEXTILE ENGINEERING

The object of this curriculum in Textile Engineering is to provide the student with a firm understanding of scientific principles and their application to the textile industry and its related branches.

During the first two years the student is thoroughly instructed in basic mathematics, physics, and chemistry. This fundamental work is followed by more specialized training in the field of Textiles and related areas of Mechanical Engineering.

A wide range of laboratory work is included in the curriculum in order to demonstrate both the use of the experimental method in the solution of engineering problems and to give a practical understanding of textile procedure.

This curriculum is accredited by the Engineers' Council for Professional Development.

SOPHOMORE YEAR

First Semester

EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
ME	205	Introduction to Mechanical Design	(2-3)3
ME	215	Analytic Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(15-5)16

Second Semester

EE	212	Introductory Electronics	(3-0)3
MA	204	Calculus IV	(3-0)3
ME	216	Analytic Mechanics II	(3-0)3
TE	212	Fiber Science	(3-1)3
TE	264	Textile Systems I	(3-1)3
		General Elective	(3-0)3
		Total hours	(18-2)18

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	341	Thermodynamics I	(3-0)3
TE	363	Textile Systems II	(3-1)3
TE	365	Textile Systems III	(3-2)3
		General Elective	(3-0)3
		Technical Elective*	(3-0)3
		Total credit hours	18

*ROTC students will substitute AS 301

Second Semester

EE	321	Electrical Energy Conversion	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	314	Mechanical Engineering Laboratory II	(0-3)1
ME	384	Fluid Mechanics	(3-0)3
TE	366	Textile Systems IV	(3-2)3
		General Elective	(3-0)3
		Total hours	(15-5)16

SENIOR YEAR

First Semester

EC	201	Economics I	(3-0)3
ME	415	Mechanical Engineering Laboratory III	(0-3)1
ME	421	Machine Design	(2-3)3
ME	445	Heat Transfer	(3-0)3
TE	459	Textile Systems V	(2-1)2
TE	483	Engineering Design of Textile Structures I	(3-0)3
		Technical Elective*	(3-0)3
		Total hours	(16-7)18

*ROTC students will substitute AS 401

Second Semester

EC	202	Economics II	(3-0)3
ME	416	Senior Project	(0-3)1
TE	472	Textile Evaluation	(2-3)3
TE	482	Application of Scientific Methods to Textile Processes	(3-0)3
TE	484	Engineering Design of Textile Structures II	(3-0)3
TE	460	Textile Systems VI	(1-2)2
		Technical Elective (Textile)*	3
		Total credit hours	18

*ROTC students will substitute AS 402

TEXTILE TECHNOLOGY

This course of study is designed to equip its students with a well-rounded understanding of the theory and principles relating to the processing of textile materials. At the same time it provides the scientific basis necessary to understand and apply this technological knowledge. Basic purpose of the program is to prepare students to become competent textile technologists for eventual supervisory, administrative, or executive positions within the industry and its allied fields. To achieve this end, a comprehensive course covers the basic theory, principles, and applications of the major phases of textile manufacture utilizing all the common fibers, both natural and man-made, and all fabricating processes.

SOPHOMORE YEAR

First Semester

EC	201	Economics I	(3-0)3
EE	211	Fundamentals of Electricity	(3-0)3
MA	203	Calculus III	(3-0)3
ME	215	Analytic Mechanics I	(3-0)3
PH	201	Physics	(4-2)4
		Total hours	(16-2)16

Second Semester

EC	202	Economics II	(3-0)3
EE	212	Introductory Electronics	(3-0)3
MA	360	Digital Computer Programming	(3-0)3
ME	205	Introduction to Mechanical Design	(2-3)3
ME	216	Analytic Mechanics II	(3-0)3
TE	212	Fiber Science	(3-1)3
		Total hours	(17-4)18

JUNIOR YEAR

First Semester

MA	383	Statistical Methods	(3-0)3
ME	377	Elements of Materials Science*	(2-0)2
TE	305	Textile Mechanism	(3-0)3
TE	335	Design and Analysis of Woven Structures	(3-0)3
TE	411	Technology of Yarns I	(2-2)3
		General Elective	(3-0)3
		Total hours	(16-2)17

*ROTC students will substitute AS 301

Second Semester

EE	321	Electrical Energy Conversion	(3-0)3
ME	344	Heat and Power	(3-0)3
ME	384	Fluid Mechanics	(3-0)3
TE	336	Fabric Technology I	(2-2)3
TE	412	Technology of Yarns II	(2-2)3
		General Elective	(3-0)3
		Total hours	(16-4)18

SENIOR YEAR

First Semester

ME	421	Machine Design**	(2-3)3
TE	433	Technology of Knitting	(2-2)3
TE	437	Fabric Technology II	(2-2)3
TE	457	Technology of Finishing I	(3-0)3
TE	483	Engineering Design of Textile Structures I	(3-0)3
		General Elective	(3-0)3
		Total hours	(15-7)18

**Recommended, but may be substituted by a textile or other approved elective.

Second Semester

TE	458	Technology of Finishing II	(1-2)2
TE	472	Textile Evaluation	(2-3)3
TE	474	Instrumentation for Textiles	(2-2)3
TE	484	Engineering Design of Textile Structures II	(3-0)3
TE	485	Statistical Quality Control — Textile*	(3-0)3
		General Elective	(3-0)3
		Total hours	(14-7)17

*ROTC students will substitute AS 402

SUBJECT DESCRIPTIONS

Subjects are listed alphabetically under the following headings:

AS Aerospace Studies
BA Business Administration
BI Biological Sciences
CE Civil Engineering
CH Chemistry
CN Chemical Engineering
DP Data Processing
EC Economics
EE Electrical Engineering
IM Industrial Management
LL Languages and Literature
MA Mathematics
ME Mechanical Engineering
MY Meteorology
NU Nuclear Engineering
PA Paper
PH Physics
PL Plastics
RS Radiological Sciences
SS Social Sciences
TE Textiles

SUBJECT NUMBERS

The number following the letter symbols is composed of three digits. The first digit indicates the college year when the subject is normally studied, e.g., LL 111 is a freshman subject, but LL 474 is a senior subject. Subjects in the 500 series are normally for graduate students but may be taken by undergraduates in certain cases with special permission.

Odd numbers usually designate subjects offered in the first semester; even numbers designate subjects offered in the second semester. Some subjects are given both semesters without change in number. Hyphenated numbers indicate subjects continuing throughout the year.

PREREQUISITES

Prerequisites and restrictions are shown in brackets, e.g., [CH 423]. No student can be officially registered in a subject until the indicated prerequisites have been satisfactorily completed.

CLASS AND CREDIT HOURS

Numbers following the names of the individual subjects indicate within parentheses the number of hours of lecture or recitation and of laboratory; after the parentheses, numbers indicate credit hours. For example, (2-6)4 means 2 hours of lecture or recitation and 6 hours of laboratory for 4 credits; (2-3) (1-6)6 indicates 2 hours of lecture or recitation and 3 hours of laboratory for the first semester followed by 1 hour of lecture or recitation and 6 hours of laboratory the second semester, for a total credit of 6.

AEROSPACE STUDIES

AS 101-102 World Military Systems I (1-1) (1-1)2

An introductory course exploring the causes of the present world confilict, the role and relationship of military power to the conflict and the responsibility of an Air Force Officer. The course begins with a brief study of war and the principles of war. It continues with an examination of the factors of national power, the instruments tht nations use to pursue their objectives and how these relate to the varying scopes and intensities of conflict. This is followed by a broad discussion of the US military establishment and the relationship of the three military services within the DOD. The course ends with an examination of the specific functions of US Strategic Offensive and Devensive Forces in depth.

AS 201-202 World Military Systems II (1-1) (1-1)2

A continued study of world military forces with a review of the organizational structure, mission, operations and hardware of US Forces. This is followed by an analysis of the US General Purpose Forces, the US Aerospace Support Forces and a study of the specific contributions of each to US national objectives. The course ends with the study of the source of conflict in the world today and an assessment of the progress and prospects for peace in the future.

AS 301-302 Growth and Development of Aerospace Power I and II (3-1) (3-1)6

A survey course about the nature of war; development of airpower in the United States; mission and organization of the Defense Department; Air Force concepts, doctrine and employment; astronautics and space operations; and the future development of aerospace power, including US space programs, vehicles, systems, and problems in space exploration. The above areas are studies through the media of briefings, discussions, debates and written reports by the student to improve his communicative skills.

AS 401-402 The Professional Officer I and II (3-1) (3-1)6

A study of professionalism, leadership, and management, including the meaning of professionalism; professional responsibilities; the military justice system; leadership theory, functions and practices; management principles, and functions;

problem solving; and management tools, practices and controls. The above areas are studied through the media of discussions, briefings and written reports by the student to improve his ability to communicate.

BUSINESS ADMINISTRATION

BA 141-142 Accounting I and II (3-0) (3-06

Accounting concepts and techniques as tools for administration of the economic activity of the business enterprise. Methods of recording, reporting, and interpreting the financial data of the business unit.

BA 191-192 Science and Industry I and II (3-0) (3-0)6
[For BA students only]

A review of the major science areas with particular attention to their application in industry.

BA 241-242 Accounting III and IV (3-0) (3-0)6
[BA 142]

Greater analysis of the fundamental processes of accounting, with special attention to the major areas of the balance sheet and the effect of asset revaluations upon the accounts and statements.

BA 321 Marketing Principles (3-0)3
[EC 202, or EC 201 taken concurrently]

Analysis of modern methods of marketing and merchandising as they are related to consumer, producer and middleman.

BA 322 Marketing Problems (3-0)3
[BA 321]

An analytic approach to marketing strategy in relation to the problems of organization, coordination, and control. Price policies, the government's role in marketing, and physical distribution.

BA 324 Industrial Marketing (3-0)3
[BA 321]

Special problems of marketing industrial goods. Distribu-

tions channels, price policies, product line planning, and marketing stratergy. Cases will be used.

BA 325 **Advertising** **(3-0)3**
[BA 321]

The relation of advertising to modern business organization and its place in marketing and distribution.

BA 326 **Marketing Research** **(3-0)3**
[BA 321, EC 212]

Measuring potential, design of experiments, data collection, sampling, questionnaires, study of promotional efforts, market testing, and controls.

BA 331 **Business Finance** **(3-0)3**
[BA 142, EC 202]

Principles of financial management, including working and fixed capital, sources of funds, financial statements, budgeting and capitalization.

BA 332 **Money and Banking** **(3-0)3**
[EC 202]

The role of money and monetary policy in the United States. The banking structure, the Federal Reserve System, other financial institutions, and international monetary systems.

BA 334 **Investment Management** **(3-0)3**
[BA 331]

Principles of investment, including security analysis, portfolio management and market analysis.

BA 341-342 **Accounting V and VI** **(3-0) (3-0)6**
[BA 242]

Advanced accounting comprising the bridge between accounting principles and the actualities of large-volume modern business. The measures and means necessary to marshal accounting information for internal control and for service to management at all levels.

BA 344 **Cost Accounting** **(3-0)3**
[BA 142]
[For Accounting Majors]

Job lot, process, and standard cost systems, including

joint and byproduct problems, and the managerial uses of cost data.

BA 346 Managerial Accounting (3-0)3
[BA 142]
[For Non-accounting Majors]

The use of cost accounting from the point of view of the business manager. Job lot, process, and standard cost systems are utilized.

BA 362 Business Law (3-0)3

Principles of commercial law encompassing a study of contracts, agency, employment, commercial paper and sales including the Uniform Commercial Code.

BA 363 Advanced Business Law (3-0)3
[BA 362]

The analysis of the legal principles underlying real and personal property, corporations, partnerships, trusts and estates.

BA 371-372 Production Management I and II (3-0) (3-0)6

The internal organization and productive process of the manufacturer, including the management functions of planning, directing, and administration in relation to production. Plant layout, materials handling, inventory and quality control. The first semester is a principles course and the second semester is primarily a problems course utilizing the case method.

BA 402 International Business (3-0)3
[EC 202]

The distinctive features of international commerce, including government policies, multinational corporate problems, foreign exchange, tax problems, and special licensing and agency arrangements.

BA 403 Electronic Data Processing (3-0)3

The role of digital computers in the solution of management problems. The preparation and solution of sample problems on the Institute's computer installation.

BA 421 Procurement (3-0)3
[BA 321]

Purchasing procedure, quality control, inventory control,

source selection, forward buying, and speculation, as applied to the individual enterprise.

BA 423 Marketing Management (3-0)3
[BA 321]

Problems of marketing, especially from the point of view of the formulation of business policy.

BA 426 Sales Management (3-0)3
[BA 321]

Management of the selling function in its broad aspect. Sales organization, compensation, selection, training, and supervision. Market research, product packaging and development, and distribution policies.

BA 431 Financial Management (3-0)3
[BA 242, BA 331]

Advanced study of financial management principles. Emphasis on problem analysis and problem solving.

BA 441 Auditing (3-0)3
[BA 342]

Duties and responsibilities of the auditor, kinds of audits, programs of audit, and auditor statements and reports.

BA 444 Advanced Cost Accounting (3-0)3
[BA 344]

Estimated cost systems, budgeting control with standard costs, and cost and profit analysis for decision-making purposes.

BA 445 Tax Accounting (3-0)3
[BA 242]

Tax problems of partnerships, corporations, reorganizations, personal holding companies, trusts, gifts, and estates. Problems and interpretations of the internal revenue code and regulations of both the Federal and State agencies.

BA 451 Personnel Management (3-0)3

The techniques of recruiting, selecting, training, and planning of members of the work force, including such matters as

employee health and safety, welfare, education, and wage and salary administration.

BA 452 **Industrial Relations** **(3-0)3**
[BA 451]

Human interaction and group behavior in organized industrial settings, Interpersonal intergroup conflict, motivation, and leadership.

BA 481 **Insurance** **(3-0)3**

Theory of risk, physical and moral hazards, types of insurance carriers, and basic features of each of the principal kinds of insurance.

BA 492 **Transportation** **(3-0)3**

Social and economic aspects of transportation problems as revealed by analysis of the nature, history, and problems of transportation agencies in the United States.

BA 500 **Research Seminar** **3**
[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

BIOLOGICAL SCIENCES

BI 201 **Principles of Biology** **(3-3)4**

Part one of a beginning course dealing with the structure, function and diversity of living organisms which includes an introduction to cell structure, cellular metabolism, molecular genetics, protein synthesis and the ecology of representative protozoa, bacteria and viruses.

BI 202 **Principles of Biology** **(3-3)4**
[BI 201]

Part two of a beginning course dealing with the structure, function and diversity of living organisms which includes a brief survey of the animal and plant kingdoms, photosynthesis, developmental biology, ecology and evolution.

BI 301 Physiology (3-3)4

Structural, chemical and physical aspects of important processes in mammals. Mechanisms operative at the molecular, cellular, and organismic levels related to (1) intake, transport, metabolism and excretion of gases and nutrients, (2) immune protection, (3) muscle contraction and (4) integrative activity of the nervous and endocrine systems.

BI 311 Microbiology (3-3)4

A study of the morphology and the chemical and physical activities of representative bacteria, yeasts, molds, viruses and animal parasites as related to man. The laboratory covers basic qualitative and quantitative techniques of microbiology with an introduction to selected immunochemical methods.

BI 330 Ecology (3-3)4

A course dealing with factors responsible for the relationships of living organisms to each other and to their natural environment. The nature and dynamics of the biotic community.

BI 370 Genetics (3-0)3

The laws of biological inheritance. The molecular basis of heredity is stressed. Replication of DNA, genetic codes and fine structures of chromosomes are considered.

BI 410 Industrial Biology (3-0)3

Fundamental aspects of physiology and microbiology followed by a consideration of the effects of chemical and microbial pollutants of air and water on biological systems. Pollution control, sanitation, food preservation as related to industrial management. Not open to biology majors.

BI 411-412 Research in Biology (0-12) (0-12)8

An individual, directed research program for senior biology majors selected on the basis of previous academic performance at the end of the junior year. Presentation of an acceptable thesis plan at the time of registration, is required.

BI 451-452 Seminar in Biology (1½-0) (1½-0)2

Seminar discussion of selected topics of current research interest. Offered each semester by a different staff member in his special discipline. Student participation in the form of discussion and presentation of papers. For senior biology majors.

BI 462 **Radiation Biology** **(3-0)3**

A study of the interactions of radiations with living systems. The effects of ionizing radiation at the molecular, cellular and organismic levels. The acute and late effects in whole animals and the modification of radiation exposure by physical, chemical and biological factors.

BI 481 **Immunology** **(3-3)4**

Lectures dealing with the theories of infection and immunity are correlated with a laboratory study of antigens, antibodies, and antiserums emphasizing immunochemical techniques.

BI 482 **Immunoparasitology** **(3-3)4**

The principles of animal parasitism are considered. The immunological aspects of the host-parasite relationship are stressed.

CIVIL ENGINEERING

CE 201 **Surveying I** **(3-4)4**
[MA 103; ME 104]

Principles of data gathering by surveying processes for the measurement and determination of lengths, directions, coordinates, areas, volumes and topographic information. Illustrative fieldwork to give facility in basic surveying techniques; problems are used to demonstrate processing of field data.

CE 202 **Surveying II** **(3-4)4**
[CE 201]

Application of basic surveying techniques to the solution of engineering problems implicit in such Civil Engineering areas as transportation, industrial and domestic structures, utilities for the safety and convenience of humans, and water supply and control. Fieldwork projects typical of application of surveying to Civil Engineering

CE 312 **Structures I** **(3-0)3**
[ME 220]

An introduction to the principles of structural analysis with applications to typical Civil Engineering structures. Emphasis will be on the analyses of statically determinate planar structures.

CE 322 **Hydraulics** **(4-0)4**
[ME 309]

Principles and physical properties of fluids at rest and in motion through open and closed conduits. An introduction to the basic concepts of hydrodynamics and hydraulic similitude.

CE 341 **Transportation** **(3-3)4**
[CE 202]

Development of the basic principles pertaining to the movements of people and materials by modern routes of transportation such as highways, airlines, railways, water routes and pipelines. Areas covered include geometric design, traffic, materials of construction and the basic concepts of transportation economics, finance and administration.

CE 411 **Structures II** **(3-3)4**
[CE 312]

Analysis of statically indeterminate Civil Engineering structures employing classical and modern methods and treated as the initial steps in the total design concept.

CE 412 **Structures III** **(3-3)4**
[CE 411]

Design of structural elements and connections subjected to all types of stresses. Use and critical review of current design codes and application of these design principles to typical structures.

CE 413 **Concrete** **(3-3)4**
[CE 312]

Fundamental principles and concepts essential to the design and analysis of reinforced concrete structures. Research and its influence on design codes, study of elastic and inelastic behavior, and treatment of the rational foundations of design.

CE 421 **Hydrology** **(3-3)4**
[CE 322]

Theoretical principles underlying the use of the hydrologic phenomena of precipitation and water losses in the analysis and design of hydraulic structures. Methods of estimating stream flow under normal and flood conditions.

CE 431 **Soil Mechanics I** **(3-0)3**

[CE 312]

Development of the fundamental principles of the science of soil mechanics as utilized in foundation engineering. Includes bearing capacity, percolation properties and settlement characteristics of soils as they affect the design of Civil Engineering structures.

CE 432 **Soil Mechanics II** **(3-3)4**

[CE 431]

Advanced theory of soil mechanics and its application to engineering analysis and design. Includes earth pressure theories, slope stability analysis, and the design of retaining structures and embankments. Introduction to soil mechanics laboratory practice covering determination of fundamental soil properties and behavior.

CE 961 **Advanced Surveying** **(2-1)2**

[MA 32]

[For students in Engineering Technology only]

Application of higher surveying techniques to the providing of information and the solution of engineering problems. Topics covered include precise measurement of distances; precision measurement of angles; methods of determining elevations with high precision; consideration of photogrammetric techniques; and the basic principles of engineering astronomy.

CE 971 **Structures** **(2-1)2**

[CE 52]

[For students in Engineering Technology only]

Review of elementary analysis of determinate structures with applications to more complex structures. Influence lines and their applications. Calculation of deflections of beams, frames and trusses. The analysis of indeterminate beams, trusses and simple frames by currently applicable methods.

CE 981 **Structural Analysis and Design** **(3-3)4**

[CE 971; MA 76]

[For students in Engineering Technology only]

Analysis and design of beams and frames. Design of structural elements under typical stresses by use of current design codes.

CE 982 Hydrology (3-3)4

[CE 961]

[For students in Engineering Technology only]

A practical treatment of the occurrence and distribution of rainfall, surface and groundwater flow. Use of hydrologic factors as components in the design of hydraulic structures.

CE 991 Concrete Analysis and Design (3-3)4

[For students in Engineering Technology only]

The review and extension of the application of current methods to the analysis and design of reinforced concrete structures. Use of design aids to facilitate the solution of selected problems.

CE 992 Soil Mechanics (3-3)4

[CE 971]

[For students in Engineering Technology only]

Introduction to soil mechanics including laboratory techniques, all with the emphasis on the application of principles. Encompasses the use of field and laboratory tests in the design of foundations and the treatment of highway embankments. Laboratory work includes soil classification, gradation tests, Atterberg limits, and the common soil strength and compressibility tests.

CE 995 Engineering Laboratory (0-3)1

[CE 971]

[For students in Engineering Technology only]

Introduction to the basic techniques in the testing of engineering materials to establish experimentally the basic stress and strain indices. Introduction to experimental stress analysis by laboratory methods.

CE 996 Engineering Problems (1-2)1

[For students in Engineering Technology only]

Topical discussions covering the relationship of the engineer to such groups as the general public, governmental agencies, clients and contractors, legal entities, and other engineers. Case studies include engineering concerns in such areas as contracts and specifications, regulatory agencies including zoning boards, boards of appeals, and conservation agencies.

CHEMISTRY

CH 001-002 Chemical Principles (4-0) (4-0)6

An introduction to the structure and reactivity of chemical species based on the periodic properties of the elements. Physical aspects of chemical theory are stressed and correlated.

CH 003-004 Chemical Principles Laboratory (0-2)2

The presentation of chemical principles in the form of concrete examples with illustration of the methods of an experimental science. Emphasis is placed on training in scientific observation, systematic recording of data and the derivation of conclusions from experimental results.

CH 205 Qualitative Analysis (3-0)3

[CH 002]

[Primarily for students not majoring in chemistry.]

A lecture course dealing with the physical chemistry of aqueous electrolytic solutions. The nature and behavior of solutes and solutions; reaction rate theory and its relation to solubility, proton transfer, and other types of equilibria; and application of the above principles to problems of separation and identification

CH 207 Inorganic Chemistry (3-4)4

The chemical behavior, electronic and geometric structures, methods of preparation, reactions, and nomenclature of some of the more common elements and their compounds as well as some of the better-known transition and inner-transition elements. The laboratory deals with the preparation and study of some of the more interesting compounds.

CH 210 Analytical Chemistry I (3-4)4

[CH 002, CH 221, CH 232 concurrently

[Primarily for students majoring in chemistry]

The fundamental principles of analytical chemistry, both qualitative and quantitative, including the separation, identification, and quantitative measurement of substances through chemical methods, chromatography, ion exchange, microscopy, fluorometry, and spectroscopy.

CH 211 **Quantitative Analysis** **(3-4)4**

[CH 002]

[Primarily for students majoring in Plastics Technology]

The fundamental principles of quantitative analysis. The principles and calculations of gravimetric and volumetric analysis, including some coverage of industrial applications.

CH 221-222 **Organic Chemistry** **(3-4) (3-4)8**

[CH 002]

[Primarily for chemistry majors]

The classification, nomenclature, structure, mechanism of reaction, and behavior in bulk of important kinds of organic species. The laboratory work illustrates the experimental techniques which can be used to react, purify, characterize, and identify organic substances.

CH 223-224 **Introductory Organic Chemistry** **(3-3) (3-3)8**

[CH 002]

[Primarily for students not majoring in chemistry]

A lecture and laboratory course similar to CH 221-222, but with emphasis on applications in the chemical industries.

CH 232 **Physical Chemistry** **(3-3)4**

[MA 204]

Basic physical chemical approaches to studies of gases, laws of thermodynamics, solution properties, chemical and phase equilibria. For chemistry majors only.

CH 311 **Analytical Chemistry II** **(2-4)3**

[CH 210, CH 222, CH 333 concurrently]

The lecture consists of an introduction to simple and complex equilibria, kinetics, fundamentals of instrumentation and the chemical and instrumental bases of the tools of modern chemical analysis.

The laboratory furnishes instruction in fundamental analytical techniques from gravimetric and volumetric methods to use of modern instrumental techniques to separate, purify and determine the structure of unknown organic and inorganic compounds.

CH 321 Organic Chemistry Laboratory II (1-6)3
[CH 222]

A continuation of CH 222 laboratory involving additional laboratory work in organic chemistry with emphasis on modern techniques of synthesis.

CH 333 Physical Chemistry (3-3)4
[CH 232]
[For chemistry majors only]

Introduction to principles of statistical mechanics, kinetics, electrochemistry, and atomic and molecular structure.

CH 335-336 Principles of Physical Chemistry (3-3) (3-3)8
[CH 205, MA 203]

Similar to CH 232-333 but designed for students not majoring in chemistry.

CH 342 Organic Qualitative Analysis (1-6)3
[CH 222]

Methods of identification of "unknown" organic substances whose properties have been previously published in the chemical literature.

CH 403-404 Chemistry of High Polymers (3-4) (3-4)8
[CH 222 or 224, CH 333 or 336]

The physical and organic chemistry of monomers and polymers, including a consideration of non-bonding forces, spectroscopic methods of structure determination, structure and property correlations, fractionation, thermodynamics, and methods of molecular weight determination for polymers in solution; the kinetics of condensation and addition polymerization as applied to polymers and copolymers, mechanism of free radical and ionic polymerization, stereo-specific polymers, the chemistry of the more common polymers systems, and preparation of their corresponding monomers.

CH 407-408 Advanced Studies in Chemistry (0-9)(0-9)6
[Permission of Department Head and instructor]

Advanced work in analytical, organic, inorganic and physical chemistry, including literature survey, laboratory work, and reports. Two semesters must be taken.

CH 422 Biochemistry (3-3)4
[CH 222 or 224; CH 232 or 336 concurrently]

Fundamental concepts in biochemistry including protein structure and biosynthesis; enzyme structures and mechanisms; nucleic acids and genetic development; metabolism; photosynthesis; cellular structure; functions and structure of carbohydrates, hormones, lipids, and hemins; chemical functions of organs.

CH 423-424 Advanced Organic Chemistry (3-0) (3-0)6
[CH 222]

Extension of first-year organic chemistry to include additional classes of compounds and special topics. Emphasis is placed on synthetic methods, including the mechanism, scope, and limitations of the important name reactions in the field of synthetic organic chemistry.

CH 431-432 Advanced Physical Chemistry (3-0) (3-0)6
[CH 333 or equivalent]

An extension of introductory physical chemistry for undergraduate majors and first-year graduate students in chemistry and related fields, with emphasis on classical and statistical thermodynamics as they apply to the various chemical phenomena.

CH 434 Colloid and Surface Chemistry (3-0)3
[CH 232 or CH 335]

Theory of colloidal systems including physical chemistry of surfaces, electrokinetic phenomena and molecular kinetic and optical properties of colloids. Consideration is also given to thin layers and to foams and emulsions including the preparation of lyophobic colloidal systems, and the stability of lyophobic sols.

CH 442-443 Advanced Inorganic Chemistry (3-0) (3-0)6
[CH 333]

A treatment of the structure and reactions of the inorganic elements and their compounds, with emphasis on physical-chemical principles. Included are such topics as wave mechanics and the theory of the chemical bond, spectroscopy, inorganic stereochemistry, crystal field theory, reactions in nonaqueous solvents, coordination chemistry, and atomic structure, including the structure of the atomic nucleus.

CH 481-482 Radiochemistry (2-3)3
[CH 002, MA 204, PH 201]

Fundamentals of radiochemistry, including radioactivity, atomic nuclei, nuclear reactions, reactors, and radiation detection and measurement, with emphasis on the use of radioactive materials in chemical applications. Designed primarily for majors in chemistry and in allied fields.

CH 484 Elements of Radiochemistry (2-3)3

Chemical principles are reviewed and their applications to radiochemistry are discussed. Such topics as separation procedures and chemical identification of nuclides, radiation chemistry, and study of fission products are included in the course.

CH 502 Absorption Spectrophotometry and Color Measurement (2-3)3

Theory and application of absorption spectrophotometry to the qualitative and quantitative analyses of chemical substances in both transparent and opaque media in the ultraviolet, visible, and near infrared ranges, including theories of color, vision, and subjective color evaluation.

CH 503-504 Chemistry of High Polymers (3-0) (3-0)6
[CH 222, CH 333]

An introduction to the physical and organic chemistry of high polymers for graduate students. Similar to CH 403-404 but with additional assigned reading.

CH 505-506 Techniques of Polymer Chemistry (0-4)2

A laboratory subject to be taken concurrently with CH 503-504 and designed to acquaint a graduate student majoring in Polymer Science with the techniques used in the preparation, characterization, and investigation of macromolecular substances.

CH 509-510 Introduction to Polymer Physics (2-0) (2-0)4

Elements of chain statistics, bonding in polymer, segmental and molecular motion, first and second order transitions, rubber elasticity, viscosity, viscoelasticity, mechanics of network response, electrical and optical properties of polymers, crystalline state in polymers.

CH 511 **Spectroscopy** **(3-0)3**
[CH 431-432]

A presentation of molecular spectra and molecular structure is presented to illustrate the empirical results and the theoretical background necessary to interpret the results.

Offered in alternate years.

CH 513 **Nuclear Magnetic Resonance and Electron Spin Resonance Spectroscopy** **(3-0)3**
[CH 431-432]

An introduction to the essentials of nuclear and electron spin resonance is presented to illustrate the scope and applications of the method.

Offered in alternate years.

CH 514 **Advanced Analytical Chemistry** **(3-0)3**
[CH 431 or equivalent]

An emphasis is placed on the determination of molecular structure by modern analytical methods, and the effect of molecular structure on chemical reactions.

CH 515 **Chemical Literature** **(1-0)1**

Use of the chemical library, journals, reference works and other technical publications pertaining to chemical subjects. Exercises in finding assembling and using such data.

CH 516 **Advanced Laboratory Technique** **(1-3)2**

A study of the theory and application of the more advanced techniques and equipment in the preparation and purification of organic compounds, including high efficiency fractionation, vacuum and molecular distillation, hydrogenation and reactions in inert atmospheres.

CH 517 **Glass Working** **(0-1)0**

Fundamental techniques in the preparation and assembling of glass apparatus.

CH 521-522 **Physical Organic Chemistry** **(3-0) (3-0)6**
[CH 424]

Modern concepts of molecular structure developed and related to the physical and chemical properties of organic com-

pounds. Polarization effects and reaction mechanisms considered in detail.

CH 523 Organic Reaction Mechanisms and Structure (3-0)3

Designed to provide insight into how reactions occur and how the reaction mechanism is studied. Emphasis is placed on bonding, substitution and elimination processes, stereochemistry, and conformational analysis. For graduate students only.

CH 524 Organic Synthesis (3-0)3

Mechanism, scope, and limitations of important selected types of reactions, and design of synthetic sequences. Emphasis is placed on reduction, oxidation, halogenation, alkylation, and acylation. For graduate students only.

CH 527-528 Stereochemistry (3-0) (3-0)6

The fundamental concepts of optical and geometrical isomerism and the relationship of the stereostructures to the physical and chemical properties of organic compounds.

Offered in alternate years.

C H 531-532 Statistical Mechanics for Chemists (3-0) (3-0)6

[CH 539 or equivalent]

A continuation of the introductory statistical mechanics presented in CH539. Current theories on such topics as configuration of polymer molecules, rubber elasticity, and solution structure, as well as principles of classical statistical mechanics.

CH 535-536 Advanced Topics in Physical Chemistry (3-0) (3-0)6

Selected topics and recent advances in physical chemistry. Selection of topics is at the discretion of the instructor.

CH 537 **Chemical Thermodynamics** **(3-0)3**
[CH 539 or equivalent]

An advanced subject in chemical thermodynamics, with emphasis on the recent mathematical developments in the description of chemical systems and with attention given to current experimental methods of obtaining thermodynamic data. The chemical and physical scientific literature is used extensively.

CH 539 **Theoretical Chemistry** **(3-0)3**
[CH 443-444 or equivalent]

The formal and group theoretical aspects of quantum chemistry particularly as they apply to molecular structure and reactivity.

CH 540 **Chemical Kinetics** **(3-0)3**
[CH 442-443 or equivalent]

The theoretical and empirical treatment of chemical kinetic data as well as the methods of obtaining these data. Determination of the order of reactions, factors influencing rates, application of rate studies in establishing hypotheses for reaction mechanism, collision theory, and absolute rate theory.

CH 543-544 **Modern Inorganic Chemistry** **(3-0) (3-0)6**

Similar to CH 443-444 but designed specifically for graduate students. Emphasis is placed on the theory of the chemical bond, bonding in complexes, coordination theory, spectroscopic methods, non-aqueous solvent systems.

CH 549 **Physical Chemistry of Macromolecules I** **(3-0)3**
[CH 503 or CH 509]

An advanced treatment of the physical chemistry of macromolecules including chain statistics, thermodynamics and optical and hydrodynamic properties.

Offered in alternate years.

CH 551 **Physical Chemistry of Macromolecules I** **(3-0)3**
[CH 503 or CH 509]

An advanced treatment of special topics in the physical

chemistry of macromolecules such as the study of polyelectrolysis solutions, transport processes in the presence of an electric field, multiple equilibria, and the kinetics of macromolecular reactions.

Offered in alternate years.

CH 553 Organic Chemistry of Macromolecules (3-0)3
[CH 404]

An advanced study in polymer science concerned with modern theoretical concepts and including synthesis, mechanism of formation, reactions and degradation of macromolecules.

Offered in alternate years.

CH 554 Stereochemistry of Macromolecules (3-0)3
[CH 404, CH 424]

A treatment of modern methods applicable to the stereochemistry of macromolecules and including homogeneous and heterogeneous catalysis, methods of analysis, synthesis, mechanism, structural consequences generated from geometry, configuration or conformation and a statistical treatment of tacticity.

Offered in alternate years.

CH 561 Advanced Organic Synthesis (3-0)3
[CH 523 and 524, or equivalent]

The application of known organic reactions to synthesis of chemical species in such fields as terpenes, steroids, alkaloids, antibotics. Theoretical implications of organic reactions are also discussed.

Offered in alternate years.

CH 564 Organic Qualitative Analysis (1-6)3

Similar to CH 342 but designed for graduate students majoring in chemistry.

CH 565 Heterocyclic Chemistry (3-0)3

Classification, nomenclature, structure, synthesis, and utility of the more important classes of heterocyclic compounds.

Offered in alternate years.

CH 568 Structural Analysis (3-0)3

Practical application of instrumental data in the determination of the structure of organic compounds. Includes mass spectroscopy, ultra violet spectroscopy, infrared spectroscopy and nuclear magnetic resonance spectroscopy.

CHEMICAL ENGINEERING

CN 203 Introduction to Chemical Engineering (3-0)3
[CH 002, MA 104]

Introduction to the fundamentals of chemical engineering. Curve plotting, introduction to chemical equilibria and kinetics. Development of flow sheets and introduction to mass balances. Review of chemical reactions and analysis of two processes.

CN 204 Chemical Engineering Calculations (3-0)3
[CN 203, MA 204 taken concurrently]

Mass and Energy balances, including phase separation and elementary thermochemistry. Steady-state calculations and applications to chemical engineering processes. Introduction to unsteady-state concepts.

CN 205 Chemical Engineering Laboratory I (0-3)1
[Taken concurrently with CN 203]

Introduction to chemical engineering concepts. The material balances, reaction rates, and orders of reactions. Phase separations and development of elementary unit process concepts.

CN 303 Chemical Engineering Principles I (3-0)3
[CN 204]

The Unit Operations concept. Study of Fluid Flow and Heat Transfer. Problem solving in these areas.

CN 304 Chemical Engineering Principles II (3-0)3
[CN 303]

Mass Transfer Operations of Distillation, Absorption, Humidification, Evaporation and Drying.

CN 311 Chemical Engineering Thermodynamics (3-0)3
[CN 303 taken concurrently]

Application of the first and Second Laws of Thermodynamics to chemical engineering problems. Heats of reaction and enthalpy changes as a function of temperature; fugacity and activity; state properties; homogeneous and heterogeneous equilibria; electrochemical effects.

CN 313 or CN 314 Process Dynamics And Control (3-0)3
[CN 204]

An introduction to chemical process control, description of processes and equipment by differential equations and the LaPlace transform. Representation of open and closed loop by block diagrams. Control loop stability is discussed together with methods of representing dynamic behavior on Bode and Nyquist diagrams and related to experimental data.

CN 315-316 Chemical Engineering Laboratory II and III (0-3) (0-3)2
[CN 303 and CN 304 taken concurrently]

Experimental projects involving various unit operations. Both group and individual projects. Written and oral reports. Application of chemical engineering principles.

CN 319 or CN 320 Special Projects Credits to be arranged

Research projects to be undertaken by the student with the supervision of a staff member. Usually will be an original problem. Reports required on project work.

CN 403 Reactor Design and Kinetics (3-0)3
[CN 304]

Review of principles underlying rates of transformation of matter and energy; effect of temperature and catalysis on chemical reactions; application to design of chemical reactors; use of digital computers in solution of problems.

CN 407 Engineering Analysis of Chemical Processes (3-0)3
[CN 304]

A qualitative and quantitative analysis of selected chemical processes from a chemical engineering and economic view-

point. Interrelationships between various segments of the industry. Reports and plant visits.

CN 408 — Engineering Materials — (3-0)3
[Approval of instructor]

Study of materials for engineering and construction purposes from the standpoint of physical and chemical structures. Study of corrosion and elementary electrochemistry. Structures of metals, non-metals and polymeric materials. Structure of materials related to performance.

CN 410 — Process Analysis and Plant Design — (3-0)3
[CN 304, CN 316]

Economic principles applied to evaluation and optimization of various chemical engineering processes. Several minor projects and one major design problem requiring written reports and oral presentation. Use of computers in design computations.

CN 416 — Profession Orientation — (2-0)0
[Given by staff members]

A series of lectures and discussion groups primarily with seniors and graduate students to acquaint them with the mechanics of business, finance and taxes, unionism, organization of businesses and what is expected by industry of a professional engineer.

CN 419 or CN 420 — Special Senior Projects — Credits to be arranged

Original research projects primarily in the chemical engineering field and supervised by a staff member of the Department. Reports required on work done.

CN 503 or CN 504 — Absorption and Extraction — (3-0)3
[CN 304]

Principles of separation; phase diagrams and multicomponent mixtures; mathematical and graphical solutions to mass transfer problems. Use of computer in some problem solutions.

CN 505 or CN 506 — Colloid Chemistry for Chemical Engineers — (3-0)3

Colloid chemistry principles applied to chemical engineer-

ing processes. Zeta potential and its applications; special problems involving surface chemistry and physics.

CN 507 or CN 508 **Corrosion and Electrochemical Principles** **(3-0)2**
[Approval of Instructor]

Electrochemical principles and physical chemistry relating to corrosion of metals. Materials of construction and design based on these principles. Prediction of metal behavior in process design.

CN 511 or CN 512 **Structure and Properties of Matter** **(3-0)3**
[Approval of Instructor]

Fundamental properties of matter as they relate to chemical engineering problems. Materials of construction. Rheological properties of polymeric materials and their application to chemical engineering.

CN 517 or CN 518 **Advanced Distillation** **(3-0)3**
[CN 503 or CN 504]

Review of principles of mass separation. Multicomponent distillation. Design of columns and anlaysis of specific systems. Use of computer in solution of distillation problems.

CN 519 or CN 520 **Advanced Chemical Engineering Thermodynamics** **(3-0)3**
[CN 311]

A critical examination of classical thermodynamics from a chemical engineering viewpoint, emphasizing the fundamental laws. General thermodynamic relations are used to develop equations for pure, ideal gases and real substances. Selected topics in applications of thermodynamics to equilibrium systems, refrigeration and other equipment.

CN 528 or CN 529 **Transport Phenomena** **(3-0)3**
[Approval of Instructor]

An advanced study of the mechanics of momentum, heat and mass transfer. The equations of continuity, motion and energy are considered for several systems in steady and unsteady state processes. Transfer coefficients are defined as a microscopic and macroscopic level and the entire subject of unit operations are defined in terms of equations of change. Considerable emphasis is placed upon solutions to problems.

DATA PROCESSING

DP 931 Scientific Computer Programming — FORTRAN **(3-0)3**

[MA 41]

[For students in Engineering Technology only]

A detailed study of the FORTRAN programming language for the Institute's computer with numerous mathematical examples and problems; introduction to advanced programming techniques and large data processing systems. Student will program several basic problems to completion.

ECONOMICS

EC 201-202 Economics I and II **(3-0)(3-0)6**

The foundations and nature of economic principles. National income, money and banking, and monetary and fiscal policy. Price and production theories, the distribution of income, comparative economic systems, and a brief survey of economic doctrines.

EC 211-212 Economic Statistics I and II **(3-0)(3-0)6**

Measures of central tendency, dispersion, frequency distributions, probability distributions, tests of hypotheses, regression analysis, multiple and partial correlation, time series, seasonal variations, index numbers, and analysis of variance.

EC 301 Economic Development of the United States **(3-0)3**

A study of the influence of science and technology upon the economic development of the United States.

EC 302 Labor Economics **(3-0)3**

[EC 202]

The effect of American capitalism on the position of labor. The rise of union organization and the factors in its growth. Trends in the labor force, money and real wages, wage problems and wage differentials, problems of hours and working conditions, and causes and remedies for unemployment.

EC 303 **Microeconomic Theory** **(3-0)3**
[EC 202]

An advanced examination of price and production theory, the theory of the household and the firm.

EC 304 **Macroeconomic Theory** **(3-0)3**
[EC 202]

An analysis of Keynesian and post-Keynesian theory. National income accounts, monetary and fiscal policy, and econometric models.

EC 402 **Government and Business** **(3-0)3**
[EC 202]

An examination of federal, local and state controls on business activity, with emphasis on the economic interpretation of the various statutes and court decisions involving business.

EC 403 **International Trade Theory** **(3-0)3**
[EC 202]

The classical and modern trade theories. International payments, exchange and trade controls, and international trade policy determinants.

EC 404 **Comparative Economic Systems** **(3-0)3**
[EC 202]

Income distribution and resource allocation in centrally-planned as opposed to market-oriented economics. Emphasis on output decisions, role of price, problems of consistency and efficiency, success indicators, and incentives.

EC 407 **Econometrics** **(3-0)3**
[EC 212, 304]

The course will provide the student both theoretical and empirical knowledge of econometrics. Methods of handling data, quantative empirical estimates, and tests of economic theory.

EC 408 **History of Economic Thought** **(3-0)3**
[EC 303]

Analysis of the development of economic theory; emphasis on the rise of classical economic thought.

EC 409 **National Income and Business Cycles** **(3-0)3**
[EC 202]

Analysis of the relationship between national income, total spending and the price level. The nature and cause of changes in the level of business activity. Business cycle theories, forecasting and the problems of instability.

EC 410 **Economic Development of Less Developed Countries** **(3-0)3**
[EC 202]

The role of capital (private and social), technology, labor, government, international trade, socio-cultural and institutional factors in development. Analysis of capital/output ratios, social marginal product, disguised unemployment and overpopulation theories. Critical analysis of development strategies.

EC 411 **Public Finance** **(3-0)3**
[BA 332]

Study of alternative methods of financing non-market enterprises. Special emphasis on the tax and expenditure policies of federal, state and local governments.

EC 412 **Managerial Economics** **(3-0)3**
[EC 202]

An economic approach to management decisions. This subject draws upon economic analysis to help formulate policy in such matters as capital budgeting, multiple product decisions, demand analysis and competitive action.

EC 414 **Engineering Economy** **(3-0)3**
[EC 202]

The significance of the economic aspects of engineering. The economic feasibility of engineering projects, capital replacement problems, break-even analysis, depreciation and obsolescence, and operational economy.

EC 500 **Research Seminar** **(3-0)3**
[Permission of Department Head]

An honors course to permit the advanced student to do research in topics of special interest in economics under faculty supervision.

ELECTRICAL ENGINEERING

EE 201-202 Introductory Circuit Theory (4-0) (4-0)8
[MA 104, PH 201 concurrently]

An introduction to the study of the mathematical and physical aspects of electrical circuits in which radiation in the form of electromagnetic waves does not play a major role. Kirchhoff's laws, Thevenin's theorem, reciprocity, and other network theorems, funicular diagrams, complex algebra, coupled circuits, sinusoidal steady-state and transient behavior are discussed.

EE 207-208 Basic Electrical Engineering Laboratory (1-3)(1-3)4
[EE 201 concurrently with EE 207]

Primarily devoted to experimental work designed to acquaint the student with electrical instruments and the techniques of electrical measurements and to provide experimental verification of the behavior of passive electrical circuits.

EE 211 Fundamentals of Electricity (3-0)3
[MA 104, PH 201 concurrently]
[Not open to students majoring in Electrical Engineering]

An introduction to electric circuits. Direct-current circuits, network theorems, energy storage elements, solution of equilibrium equations, complex impedance, analysis of steady-state a.c. circuits, two-terminal networks, and two-terminal-pair networks.

EE 212 Introductory Electronics (3-0)3
[EE 211]
[Not open to students majoring in Electrical Engineering]

A background subject in electronics presenting the properties and uses of vacuum tube and semiconductor devices.

EE 214 Electrical Machinery Laboratory (0-3)1
[EE 211]
[Not open to students majoring in Electrical Engineering]

An introductory laboratory course primarily devoted to the measurement of terminal characteristics of electrical machinery.

EE 306 **Electromagnetic Theory** **(4-0)4**
[MA 313]

Electricity and magnetism presented from the field theory point of view, using vector analysis and Maxwell's equations. The static electric field in polarizable and conducting media, static magnetic fields of steady electric currents and ferromagnetic materials; time-changing electric and magnetic fields, magnetic induction, electromagnetic waves and energy flow, and boundary value problems.

EE 311-312 **Electronics Laboratory** (1-3) (1-3)4
[EE 208; EE 319 and 320 concurrently]

An intermediate course primarily devoted to laboratory exercises in which the experiments are designed to stimulate an appreciation for the limitations of basic electronic equipment. The experiments are closely coordinated with allied courses and provide experimental verification of the properties of electronic devices and circuits.

EE 315 **Network Analysis** **(4-0)4**
[EE 202, MA 204]

Complete solutions of linear passive networks; response of linear systems to exponential functions; signal representation by Fourier series, Fourier transforms, bilateral Laplace and unilaterial Laplace transforms; solutions to linear systems problems using frequency analysis and transform analysis; selected topics from complex variable theory, distortionless transmission, convolution, stability, and signal flow graphs.

EE 318 **Digital Computation in Electrical Engineering** **(3-3)4**
[EE 201 or EE 211]

The application of digital computers to the solution of electrical engineering problems with emphasis on compiler languages such as FORTRAN. Example problems are chosen to parallel material treated in other electrical engineering courses where possible. Computer aided circuit design and digital simulation techniques are introduced with specific examples in ECAP and PACTOLUS.

EE 319 **Electronics I** **(4-0)4**
[EE 202 and PH 201]

Detailed derivation of the charge control, hybrid π and

Ebers-Moll models of the transistor from basic principles of field theory. Introduction to the fundamental concepts of electronics including break point analysis, piecewise linearization, active circuit theory and incremental analysis.

EE 320 Electronics II (4-0)4
[EE 319]

A detailed study of electronic circuit design including operating point stability, h parameters, cascading of stages, frequency response of linear amplifiers, feedback amplifiers and other topics.

EE 321 Electrical Energy Conversion (3-0)3
[EE 211, MA 203]
[Not open to students majoring in Electrical Engineering]

The generation, control, utilization and conversion of electrical energy.

EE 351 Industrial Electronics (3-0)3
[For students majoring in Industrial Management only]

The principles of alternating currents as a background for the understanding of electronic circuits; the elements of vacuum tube, gaseous-tube and semiconductor device characteristics and of circuits utilizing such devices for the purpose of rectification, amplification and oscillation; and industrial photoelectric and time delay relays.

EE 353 Electrical Controls and Power Circuits (3-0)3
[MA 203]
[Not open to students majoring in Electrical Engineering]

Power requirements in single-phase and three-phase power circuits; operating characteristics of various types of direct-current and alternating-current motors and generators; manual and automatic electric controls including photoelectric relays, time delay relays, and motor control.

EE 403 Microwave Electronics (3-0)3
[EE 306]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, generation and focusing of high-current electron beams with electric and magnetic fields, electron optics, velocity modulation, space charge wave propa-

gation and traveling wave interaction with electron beams with application to microwave amplifiers and oscillators, and antennas.

EE 409-410 Applied Electronics Laboratory (0-4) (0-4)4
[EE 312]

The purpose of this laboratory is to give the student an experimental familiarity with the nature, application and performance of various electronic devices. Emphasis is given to methods of electrical measurement and the preparation of technical reports.

EE 411-412 Logical Design of Digital Computers (3-0) (3-0)6
[EE 319 or Permission of Instructor]

Foundations for the complete design of digital computer subsystems, such as the arithmetic unit, computer memory, control, and input-output equipment with emphasis on basic circuity as well as the logical tools: flip-flops, shift-registers, logical gates, and magnetic core memories. Boolean algebra, system synthesis, coding, and error detection.

EE 413 Linear Feedback Systems (3-0)3
[EE 315]

Mathematical models of feedback systems, system characteristics and performance specifications stability; analysis techniques including root locus, log magnitude and phase diagrams, the Nyquist and Nichols plots.

EE 414 Feedback Control Systems (3-0)3
[EE 413]

Time domain analysis of feedback control systems, compensation, Truxal's synthesis procedure, complex control systems and a.c. carrier systems.

EE 416 Electronic Amplifier Circuits (3-0)3
[EE 320, EE 413]

An integrated treatment of the analysis and design of vacuum tube and transistor amplifier circuits with emphasis on the design of such circuits. The majority of circuits considered are of the small-signal catergory, i.e., Class A operation.

EE 417 Absolute and Symbolic Programming (3-0)3

[EE 318 or Permission of Instructor]

A study of machine language and assembly language programming of the moderri high speed binary computer. In addition to mathematical problem solving techniques, the use of on-line computers in data acquisition and process control is treated. Students are expected to prepare and personally process programs on the HP 2116B binary computer. Although this course is open to all qualified students, it is primarily intended as an introductory course in computer science for electrical engineering majors.

EE 425-426 Wave Shaping and Generation (3-0) (3-0)6

[EE 320]

Principles and methods of wave shaping and wave generation using active and passive elements. Timing, switching, memory devices, oscillation, and wave shaping. Free use is made of piecewise-linear approximation, the break-point method, and/or the assumed diode state in conjuction with linear network theory. Particular emphasis is given to model representation and its analysis.

EE 429 Network Synthesis (3-0)3

[EE 315, MA 313]

A review of methods of analysis useful in the study of signals; systems and their response; impedance and admittance properties relating the frequency and time domain aspects of physical circuit behavior; linear passive network theory, emphasizing the synthesis aspects; fundamental works of Foster, Cauer, Brune, Darlington, and Guillemin applied to the design of networks having prescribed driving-point and transfer characteristics.

EE 435-436 Special Topics in Electrical Engineering (3-0) (3-0)6

[Permission of Instructor]

An analytic consideration of one or more special topics selected from recent developments in the field of electrical engineering.

EE 439 Introduction to Electrical Systems (3-0)3
[EE 320 and EE 315]

An introduction to both power and communication systems, including distributed constant transmission lines, power system operation, communication systems using amplitude, angular and pulse modulation, and a survey of radio propagation.

EE 440 Electrical Communication Systems (3-0)3
[EE 439]

A continuation of the study of communication systems including the statistical properties of signals and noise, data transmission, error detection and correction, signal to noise ratio and channel capacity of various systems.

EE 444 Electrical Power Systems (3-0)3
[EE 439, EE 454 concurrently]

Design and operation of present-day power networks considered both from the viewpoint of economy and reliability including the problems of power and frequency control, system stability and fault analysis.

EE 445-446 Analog and Digital Devices and Techniques (3-0) (3-0)6
[For EE 445: EE 319]
[For EE 446: EE 445]

A survey of analog and digital devices and techniques. Primary emphasis is on general techniques although conventional analog and digital computers are discussed extensively as examples of the application of the techniques. Operational amplifiers, multipliers, amplitude and time scaling, machine organization, number systems, Boolean algebra, arithmetic operations, memory devices, analog to digital conversion, and digital to analog conversion are discussed.

EE 454 Electromechanics (3-0)3
[EE 202 and MA 204]

The principles of electromechanical energy conversion applied to rotating machinery, control systems, and devices such as microphones, loudspeakers, accelerometers, servomotors, and space vehicles. A first course for the student of electrical engineering who will use rather than design electromechanical devices.

EE 503-504 Solid-State Physical Electronics (3-0) (3-0)6
[Permission of Instructor]

A physical interpretation of the properties of materials in terms of their dielectric constant, magnetic permeability, and electrical conductivity; dielectric, ferroelectric, and piezoelectric materials; diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic, and ferrimagnetic materials; metals, semiconductors, and insulators; and applications to electrical engineering devices.

EE 505-506 Microwave Electronics (3-0) (3-0)6
[EE 306 or Permission of Instructor]

Elements of electromagnetic theory, transmission lines, impedance matching, waveguides, antennas, microwave oscillators and amplifiers, klystrons, magnetrons, and traveling wave tubes.

EE 507-508 Electromagnetics (3-0) (3-0)6
[EE 306 or Permission of Instructor]

Solution of Laplace's and Poisson's equation's in rectangular, cylindrical and spherical coordinates. Green's function and conformal transformations. Also boundary value problems, radiation, transmission lines and wave guides will be treated.

EE 509 Systems Analysis-Transform Techniques (3-0)3
[Permission of Instructor]

Theory of functions of a complex variable. Applications of transform calculus to the solution of differential equations which arise in the treatment of mechanical, acoustical, thermal and electrical systems.

EE 510 Systems Analysis-State Variable Techniques (3-0)3
[MA 533 or Permission of Instructor]

State variable formulation and solution of differential equations which arise in the treatment of mechanical, acoustical, thermal, and electrical systems with consideration of canonical forms for computer simulation.

EE 515 Nonlinear Control Systems (3-0)3
[EE 413 or Permission of Instructor]

Analytic and numerical methods for the analysis and design of nonlinear control systems. Phase plane, describing function, the methods of Lyapunov and Popov and other nonlinear analysis techniques are treated.

EE 517 Optimal Control Systems (3-0)3
[EE 413 or Permission of Instructor]

A study of the analysis and design of optimal control systems. Both deterministic and random input signals are discussed. Introduction to adaptive control systems.

EE 519 Sampled-Data Control Systems (3-0)3
[EE 413 or Permission of Instructor]

The sampling process, reconstruction of sampled signals, the Z transform. Block diagram and signal flow graph representation of sampled-data systems and the time response of such systems.

EE 521 Automata Studies (3-0)3
[Permission of Instructor]

Mathematical foundation of automata, including probabilistic logics, neuron analogs, Turing machines, and learning theory.

EE 523 Digital Computer Software (3-0)3
[EE 417 or Permission of Instructor]

A discussion of formal languages and translators with particular reference to assemblers, and compilers. Student programs are executed on available digital computers.

EE 525 Simulation Techniques (3-0)3
[EE 318 and EE 445 or Permission of Instructor]

A study of modern analog, digital and hybrid techniques for the simulation of continuous and discrete systems and processes. The student is expected to study a number of practical engineering systems through the use of simulation techniques on available analog and digital computers.

EE 529-530 Network Synthesis (3-0) (3-0)6
[Permission of Instructor]

The formulation of the fundamentals of network theory; establishing realizability conditions and synthesis techniques for various classes of networks and network functions; methods for realizing one or more networks whenever a function of the given class is prescribed.

EE 537 Introduction to Bio-Medical Engineering (3-0)3
[EE 320 or Permission of Instructor]

A survey of the use of engineering methods in the life sciences. Topics covered include instrumentation techniques and devices, computer diagnosis of disease, computer aided data analysis, telemetry, ultrasonic techniques, artificial organs, prosthetic devices, biological modeling and simulation. Necessary biological background information is introduced as needed.

EE 539 Biological Systems (3-0)3
[EE 413, EE 445 and EE 537 or Permission of Instructor]

A discussion of the application of modern control theory to the study of biological systems. Modeling and simulation techniques are emphasized. Necessary biological background information is introduced as required.

EE 545 Coding Theory (3-0)3
[MA 533 or Permission of Instructor]

Concepts and recent developments in the use of codes for error control in data handling systems. Encoding and decoding procedures and their implementation in computational algorithms and hardware organizations are investigated in detail.

EE 547 Statistical Communication Theory (3-0)3
[MA 484 or Permission of Instructor]

A study of statistical communication problems. Particular topics include the description of signals and noise as stochastic processes, optimum smoothing and prediction and statistical decision theory.

EE 548 Information Theory (3-0)3
[MA 484 or Permission of Instructor]

A study of the probabilistic measure of information trans-

mitted by information sources, the determination of the information handling capacity of communication channels and fundamental coding theorems.

EE 549 Introduction to Lasers and Masers (3-0)3
[EE 306 or PH 353; EE 403]

A first course on Lasers and Masers not requiring quantum mechanics as a prerequisite. Classical electric and magnetic dipole models are developed to describe the quantum interaction between atoms or molecules and the radiation field. This course is designed to prepare the student to read the literature on the subject.

EE 551-552 Electro-Optics (3-0) (3-0)6
[EE 306, EE 315 and EE 549 or Permission of Instructor]

Principles of optical propagation as described by the Fresnel-Kirchoff Integral and the Rayleigh Integral, concept of transform theory as applied to optical imaging systems, transform theory of conjugate focal plane of lenses in coherent optical systems, geometrical optics as described by Newtonian lens formulae and principles of holographic three-dimensional wavefront reconstruction.

EE 975 Basic Electricity (3-3)4
[PH 942, MA 41]
[For Engineering Technology students only]

An introduction to electric circuits for students who have a background in basic principles of electricity and magnetism. Includes illustrative laboratory projects.

EE 978 Basic Electronics (3-0)3
[EE 975]
[For Engineering Technology students only]

A background subject in electronics presenting the properties and applications of vacuum tube and semiconductor devices. Intended for the student who will use rather than design electronic circuits.

INDUSTRIAL MANAGEMENT

IM 351 Motion and Time Study (0-2)1

The application of methods improvement and work meas-

urement techniques. The use of the stop watch, work sampling, and operator charts in terms of application to standard systems such as M.T.M. and Work Factor.

IM 371 — Operations Research — (3-0)3

An analysis of linear probabilities systems. Concurrent presentation of examples in the area of system reliability, congestion processes, search procedures, inventory control, and other operating problems of systems.

IM 483 — Statistical Quality Control — (3-0)3
[MA 383 or EC 212]

Control charts for maintaining the quality of manufactured products and sampling plans for the reduced inspection of manufactured products and of raw materials.

IM 500 — Research Seminar — 3
[Permission of Department Head]

Designed to give the better student an opportunity, under the direction of a faculty member, to do research in, and report on, an area of special interest.

Languages and Literature

LL 109-110 — English for International Students — (3-0) (3-0)6

Training in exposition. Reading and evaluation of selections representative of the major literary types. Designed to meet the English requirement for those for whom English is a second language.

LL 111-112 — English I and II — (3-0) (3-0)6

Introduction to literature through the essay, non-dramatic prose fiction, poetry, and drama. Critical papers.

LL 209 or 210 — Technical and Scientific Communication — (3-0)3
[LL 111-112]

Training in the theory, design, and organization of reports in science and industry. Preparation of written and oral reports for specific scientific and technical problems.

LL 213 Introduction to English Literature: to 1798 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English Literature to 1798.

LL 214 Introduction to American Literature: from 1865 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of American Literature from 1865.

LL 215 Introduction to American Literature: to 1865 (3-0)3

Interpretation and criticism of selections from the major writers in the chief periods of American Literature to 1865.

LL 216 Introduction to English Literature: from 1798 (3-0)3
[LL 111-112]

Interpretation and criticism of selections from the major writers in the chief periods of English literature from 1798.

LL 218 Negro-American Literature (3-0)3
[LL 111-112]

A study of poems, plays, short stories and novels by Negro-Americans from 1920 to the present, including Langston Hughes, Richard Wright, James Baldwin, Ralph Ellison, and others.

LL 233 Comparative Literature (3-0)3
[LL 111-112]

A consideration of at least six world classics as keys to the development of modern culture.

LL 234 or 235 Shakespeare (3-0)3
[LL 111-112]

Shakespeare's chief tragedies, comedies, and chronicles. Consideration of Shakespeare's views on the nature of man.

LL 259-260 Elementary German (3-0) (3-0)6

Fundamentals of grammar and basic vocabulary. Audio-

lingual emphasis in developing proficiency in speaking, comprehension and reading. Tapes available for laboratory use. No credit for the first semester without the second.

LL 261-262 Elementary Technical German (3-0) (3-0)6

Introductory course designed for students who wish to acquire facility in translating scientific material from German to English. Introduction to fundamentals of grammar, problems of syntax and idiom, with emphasis on scientific terminology. No credit for the first semester without the second.

LL 263-264 Elementary French (3-0) (3-0)6

An introduction to the study of the French language to develop a reading knowledge. Limited practice in pronunciation and writing. No credit for the first semester without the second. For students who have had less than two years of secondary school training in French.

LL 265-266 Elementary Russian (3-0) (3-0)6

An introduction to the study of the Russian language for students who have not previously studied Russian, or for those who have studied it for not more than one year at the secondary level. Emphasis on basic grammar and on understanding both written and spoken Russian. Tapes available for laboratory use. No credit for the first semester without the second.

LL 267-268 Elementary Spanish (3-0) (3-0)6

An introduction to the language for those who have not previously studied Spanish or who have not had more than one year of the language at the secondary level. Emphasis on the language as heard and spoken, as the first step in developing skills in reading and writing. No credit for the first semester without the second.

LL 269-270 Elementary Modern Greek (3-0) (3-0)6

The fundamentals of the language will be studied with emphasis on vocabulary, reading, and writing. Stress will also be given to oral expression. No credit for the second semester without the first semester or its equivalent.

LL 311 Advanced Composition (3-0)3
[LL 111-112]

An intensive course in the rhetorical modes of exposition,

with emphasis on argumentation. Students will present and defend papers every two weeks.

LL 313 Introduction to Continental Literature (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers through the Renaissance.

LL 314 Continental Literature Since the Renaissance (3-0)3
[LL 111-112]

Interpretation and criticism of selections from major Continental writers of the Neoclassic through the modern period.

LL 316 The English Bible as Literature (3-0)3
[LL 111-112]

The several main genres of Biblical literature considered as literature.

LL 333 or 334 Problems of Philosophy (3-0)3
[LL 111-112]

An introduction to some of the persistent problems of ethics and metaphysics and the solutions offered by modern thinkers.

LL 341 or 342 Satire (3-0)3
[LL 111-112]

A study of a literary genre. Selected readings from Horace and Juvenal through Orwell and Burgess.

LL 344 Modern Poetry (3-0)3
[LL 111-112]

An inductive investigation into the trends of modern American and British poetry, with emphasis on Hopkins, Yeats, Frost, Eliot, Stevens, and Williams.

LL 345 Modern Irish Literature (3-0)3
[LL 111-112]

Irish writing from 1890 to the present, with special emphasis on the works of Yeats, Synge, O'Casey, Joyce, O'Connor, and O'Faolain.

LL 363-364 Intermediate French (3-0) (3-0)6
[LL 264 or equivalent]

An intensified study of the language through continued acquisition of audio-lingual skills with emphasis on improving reading and writing. Use of language tapes, records, newspapers, magazines and other media. French will be the language of the classroom, as far as student ability will permit. No credit for the first semester without the second.

LL 365-366 Intermediate Literary and Conversational Russian (3-0) (3-0)6
[LL 266 or equivalent]

An intensified study of the language, with increased opportunity for speaking and writing the language. Russian short stories, essays and other written material will be supplemented by language tapes and records. No credit for the first semester without the second.

LL 367-368 Intermediate German (3-0) (3-0)6
[LL 262 or equivalent]

Practice in oral and written expression with emphasis on idomatic expression, training in syntax, and composition. Second term devoted to selected reading and discussion of significant works in prose and lyric poetry to acquaint the student with outstanding authors, ideas, and movements in German literature. Tapes available for laboratory use. No credit for the first semester without the second.

LL 369-370 Intermediate Spanish (3-0) (3-0)6
[LL 268 or equivalent]

Intensified study of the language, with increased opportunity for speaking and writing. Frequent opportunity for oral presentation in small groups. Readings will include contemporary writings as well as selected masterpieces of Spanish literature. Tapes and records for laboratory use. Spanish will be the language of the classroom insofar as student ability permits. No credit for the first semester without the second.

LL 435 English Literature of the Eighteenth Century (3-0)3
[LL 111-112]

A survey of the prose and verse (excluding drama and the novel), with emphasis on the relationship between the literature and the intellectual background.

LL 436 English Romantic Poets (3-0)3
[LL 111-112]

A close study of Wordsworth, Coleridge, Byron, Shelley, and Keats. Attention will be centered on the ways each of these poets articulates characteristically Romantic ideas.

LL 437 English Literature of the Victorian Period (3-0)3
[LL 111-112]

Consideration of selected peotry and prose of the Victorian age. Readings, lectures, and discussion.

LL 467 or 468 Seminar in German Masterpieces (3-0)3

Selected reading in German Literature from the seventeenth to the twentieth century. Discussion and analysis of significant German novels, novellen, drama, and lyric poetry. May be taken only upon recommendation of the instructor.

LL 471 The Modern American Novel (3-0)3
[LL 111-112]

A consideration of the outstanding American novelists from 1920 on. Selected works of Faulkner, Hemingway, Wolfe, and others.

LL 472 The Modern British Novel (3-0)3
[LL 111-112]

The development of the novel in English literature from Conrad and Hardy through Huxley and others. Selected novels are read and discussed.

LL 473 World Drama (3-0)3
[LL 111-112]

A survey of the main currents in world drama from early Greek drama to modern European drama. Selected significant plays from the representative periods in the historical development of world drama are read and discussed.

LL 474 Modern Drama (3-0)3
[LL 111-112]

An analysis of major forces in drama from the time of Ibsen to present. Selected representative plays are read and discussed.

LL 476 Nineteenth-Century British Novel (3-0)3
[LL 111-112]

The dominant literary form of the period studies in a representative novel of each of the major novelists from Scott to Eliot, including Austen, Dickens, Thackeray and Emily Bronte.

LL 482 The American Short Story (3-0)3
[LL 111-112]

A critical survey of the growth and development of the American short story. Consideration of the works of Poe, Crane, Anderson, and others.

LL 495 or 496 Reading and Research (3-0)3
[LL 111-112]

Independent study under the guidance of individual members of the department. Consideration for admission limited to Juniors and Seniors with "B" average.

LL 961 British Literature (3-0)3
[For students in Engineering Technology only]

An introduction to British Literature from the Anglo-Saxon Period to the Contemporary Period, with emphasis on major authors and key periods.

LL 962 American Literature (3-0)3
[For students in Engineering Technology only]

An introduction to the literature of the United States from the Colonial Period to the Contemporary Period, with emphasis on major authors and historical background.

MATHEMATICS

MA 101 Mathematical Analysis I (3-0)3

Review of algebra, factoring, rectangular coordinates, functions and graphs, linear equations, exponents and radicals, quadratic equations, inequalities, variation, mathematical induction, progressions, approximate numbers, logarithms, mathematics of investment, trigonometric functions of acute angles, solution of right triangles, and logarithmic solution of right triangles.

MA 102 **Mathematical Analysis II** **(3-0)3**
[MA 101]

Trigonometric functions of any angle, solution of oblique triangles, trigonometric formulas and identities, radian measure, trigonometric curves, trigonometric equations, complex numbers, polynomials, equation and locus, straight line, circle, parabola, ellipse, hyperbola, curve sketching, parametric equations, curve fitting, permutations and combinations, probability and determinants.

MA 103 **Calculus I** **(3-0)3**

Functions and graphs, equations of straight lines, the differentiation of algebraic functions together with applications involving related rates, differentials, maxima and minima, the conics, the indefinite intergral and area under a curve.

MA 104 **Calculus II** **(3-0)3**
[MA 103]

Applications of integration including areas, volumes, length of curves, surface area, center of mass; methods of integration including parts, trigonometric substitution, and partial fractions; the differentiation of exponential, logarithmic, and trigonometric functions; hyperbolic functions, polar coordinates, parametric equations, the scalar and vector products of two or more vectors.

MA 201 **Mathematical Analysis III** **(3-0)3**
[MA 102]

Sets, set operations, logical statements, Boolean algebra, decision making bodies, binary arithmetic, digital computers (design and operation), functions and managerial planning, functions and their use in economics and business, and mathematics of investment and finance.

MA 202 **Mathematical Analysis IV** **(3-0)3**
[MA 201]

Linear programming with graphs and ordinary algebra, vector algebra and matrix algebra used in linear programming, simplex method, transportation method, differential calculus, limit concept and continuity of a function, integral calculus and applications of calculus in business operations.

MA 203 **Calculus III** **(3-0)3**
[MA 104]

The solution of differential equations including linear, exact, homogeneous, and non-homogeneous, applications of differential equations; complex functions; series including MacLaurin's, Taylor's, and Fourier's; multiple integrals and partial differentiation.

MA 204 **Calculus IV** **(3-0)3**
[MA 203]

Introduction to linear algebra including vectors in n space, linear dependence, matrices and determinants; directional derivative, gradient, chain rule, method of least squares, maxima and minima of independent variables; vector analysis including surface and line integrals, Green's, Stokes', and divergence theorems.

MA 221-222 **Linear Algebra** **(3-0) (3-0)6**

Basic properties of the real and complex number systems. Introduction to groups, rings, fields. Linear transformations and matrices in finite dimensional vector spaces. Inner products. Applications to geometry.

MA 301-302 **Advanced Calculus for Applications** **(3-0) (3-0)6**
[MA 204]

Ordinary differential equations, the Laplace transformation, numerical methods of solving differential equations, series, solutions of differrential equations, boundary value problems and orthogonal functions, vector analysis, topics in higher-dimensional calculus, partial differential equations, partial differential equations of mathematical physics, and complex variable theory.

MA 307-308 **Advanced Calculus** **(3-0) (3-0)6**
[MA 204]

Functions of one and several real variables. Metric Spaces. Basic theorems of analysis. Calculus of vectors and differential forms.

MA 313 — Engineering Mathematics — (4-0)4
[MA 204]
[For students majoring in Electrical Engineering]

Vector analysis and complex variables with emphasis on applications in Electrical Engineering.

MA 321 — Modern Algebra — (3-0)3
[MA 222]

A study of the basic structures of contemporary abstract algebra: groups, rings, modules, categories and functors. Fields and Galois theory

MA 322 — Topics in Algebra — (3-0)3
[MA 321]

Current topics in modern algebra.

MA 334 — Projective Geometry — (3-0)3
[MA 222]

Foundations of Geometry. Homogeneous coordinates. Projective spaces. Conics. Linear transformations. Surfaces.

MA 360 — Digital Computer Programming — (3-0)3
[MA 104]
[Offered both semesters]

An introduction to digital computer programming with concentration on the preparation of programs in the Fortran programming language. The Institute's computer will be used for processing of practice problems.

MA 362 — Numerical Analysis — (3-0)3
[MA 203]

Selected mathematical and numerical methods of solving engineering problems, especially those suitable for the Institute's IBM 1620; computer solutions of algebraic, transcendental, and ordinary differential equations.

MA 381-382 — Operations Research — (3-0) (3-0)6
[MA 104 or MA 202]

The use of decision models in industrial systems. Quantitative approach to industrial alternatives. Fundamentals of probability and statistics, manufacturing and production models, time

value of money, replacement analysis, statistical control, waiting line models, linear and dynamic programming, and theory of games.

MA 383 **Statistical Methods** **(3-0)3**
[MA 104]
[Offered both semesters]

The application of modern statistical techniques to the treatment of experimental data. Characteristics of distributions, significant differences, linear correlation, and analysis of variance. Introduction to the planning of industrial experiments.

MA 405 **Mathematical Statistics** **(3-0)3**
[MA 203]

Measurements of dispersion, theoretical frequency distributions, tests of goodness of fit and independence, partial and mutiple correlations; permutations, combinations, and probability; game theory.

MA 411 **Complex Variables I** **(3-0)3**
[MA 104]

Complex numbers, point sets, and elementary functions; an introduction to analytic functions; classification of singularities; line integrals; Cauchy integral formula; power series; and residues and poles.

MA 412 **Complex Variables II** **(3-0)3**
[MA 411]

Conformal mapping, Schwarz-Christoffel transformation, applications, and further topics in Theory of Functions.

MA 431 **Topology I** **(3-0)3**
[MA 307]

Topological Spaces. Continuity. Compactness and Connectedness. Product and Quotient Spaces. Metric Spaces. The fundamental group. Topological groups.

MA 432 **Topology II** **(3-0)3**
[MA 431]

Continuation of MA 431.

MA 434 **Matrix Algebra** **(3-0)3**
[MA 204]

Algebra of vectors, matrices, and determinants; linear transformations; linear vector spaces; characteristic roots and reduction to diagonal form; quadratic forms; anu applications to physics.

MA 484 **Probabilities** **(3-0)3**
[MA 204]

Elements of combinatorial analysis, introduction to probabilities, random variables and expectation, law of large numbers, central limit theorem, and elements of mathematical statistics.

MA 495-496 **Mathematics Seminar** **(1-0) (1-0)2**

Reading, reports, and problem solving, pointing toward logical integration of the student's undergraduate work.

MA 533 **Matrix Theory** **(3-0)3**
[MA 204]

Algebra of vectors, matrices and determinants; linear transformations and vectors, matrices and determinants; linear transformations and vector spaces; characteristic values and diagonal forms; calculus of matrices, matric polymomials, matric differential equations and applications.

MA 542 **Fourier Series and Boundary Value Problems** **(3-0)3**
[MA 204]

The Fourier series as a tool of analysis, orthogonal functions, convergence tests, the Fourier integral, partial differential equations of physics, and boundary value problems.

MA 575 **Operational Mathematics** **(3-0)3**
[MA 204]

The Laplace transform and its properties and uses, as in translation of a time function, and in convolution, differentiation, and integration. Elementary applications in the analysis of vibrations, deflections, and electric circuits; problems in partial differential equations; and Fourier transforms.

MECHANICAL ENGINEERING

ME 104 Design Graphics (1-0)1

The design process, sketching; pictorial methods; conventional representation; graphs, diagrams; presentation of ideas.

ME 205 Introduction to Mechanical Design (2-3)3
[ME 104]

The drawing laboratory assignments develop the students "design vocabulary" and provide him with experience in sketching typical mechanical elements such as shafts, bearings, gears, cams, etc. Methods of developing design layouts, and assembly drawings are also covered. The machine shop laboratory acquaints the student with basic manufacturing operations such as turning, milling, drilling, etc. These aspects of the course are tied together in an assigned term design project.

ME 211 Mechanics I (3-0)3
[MA 104, PH 101]

Vector concepts of force and the moment of a force; the equilibrium requirements for rigid and deformable bodies. Force and deformation analysis including statically indeterminate situations. The concept of stress and strain at a point. The stress-strain-temperature relations.

ME 212 Mechanics and Properties of Matter (4-0)4
[MA 204 taken concurrently]
[Primarily for EE students]

This course covers selected topics in Mechanics which are of fundamental importance to students majoring in Electrical Engineering. These include kinematics, Newton's laws, work, energy, free and forced harmonic oscillations, rotational motion of rigid bodies, stress and strain relationships, moduli of elasticity and wave motion. The treatment is at the intermediate level.

ME 215 Analytic Mechanics I (3-0)3
[MA 104, PH 101]
[Primarily for CN, PL, and TE students]

Statics and an introduction to mechanics of materials. Topics include vectors; force systems; moments; friction; moment of inertia; stress and strain in tension, compression, and torsion; principal stresses; and shear and moment relations.

ME 216 Analytic Mechanics II (3-0)3
[ME 215]
[Primarily for CN, PL, and TE students]

Dynamics and mechanics of materials. Topics include beam deflection; eccentric loadings; column theories; kinematics of particles and rigid bodies; kinetics of rigid bodies; principles of work, energy, impulse, and momentum; and periodic motions.

ME 220 Mechanics of Materials I (3-0)3
[MA 203, ME 211]

Stress and deformation analysis of bodies under axial, torsional, flexural, and combined loading. Composite materials. Energy methods. Buckling.

ME 271 Machine Tool Laboratory (1-3)2
[Primarily for IM and PL students]

The use of basic machine tools such as the lathe, shaper, drill-press, and milling machine, as well as the uses of measuring instruments, threads, and gears. Lectures and demonstrations cover topics such as pattern work, foundry practice, die-casting, welding, gears, and gearing.

ME 296 Materials Science (3-0)3
[CH 002 and PH 201]

Materials for use in engineering applications are presented in general terms of their mechanical behavior, the thermodynamics of their structures, and their properties as related to their atomic and crystalline structure. The specific differences and similarities between metals, polymers and ceramics are emphasized.

ME 301 Mechanical Engineering Laboratory I (0-3)1
[ME 220, ME 296, ME 309 concurrently]

Use of various testing equipment to establish material parameters used in solid mechanics analysis. Application to both new and traditional materials.

ME 304 Materials Laboratory (0-3)1
[ME 220, ME 309]

Use of various testing equipment to establish material parameters used in structural analysis.

ME 309 — Dynamics I — (3-0)3
[MA 204 and PH 102]

Kinematics of a particle with respect to fixed and moving coordinate systems of one, two, and three dimensions. The dynamics of a particle, system of particles, and rigid bodies. Angular momentum and the inertial properties of rigid bodies. Euler's Equations. D'Alembert's principle. Impulse and momentum.

ME 314 — Mechanical Engineering Laboratory II — (0-3)1
[ME 342 and ME 382 concurrently]

Tests on various energy conversion devices in order to illustrate principles of thermodynamics and fluid mechanics. The student is encouraged to design his own method of experimentation to arrive at the required results.

ME 315 — Applied Mechanics — (3-0)3
[MA 104 and PH 101]
[Primarily for IM students]

The fundamentals of statics, including such topics as force systems, laws of equilibrium, friction, centers of gravity, moments of inertia, and an introduction to dynamics.

ME 320 — Machine Design I — (2-3)3
[ME 220, ME 309]

The principles of mechanics, and commonly used theories of failure are applied to the analysis and design of typical machine elements which are subjected to various loading conditions. Laboratory work required the solution of comprehensive machine design problems that illustrate the close relationship between analysis and synthesis in design. Methods of writing clear and coherent design reports are emphasized.

ME 341 — Thermodynamics I — (3-0)3
[MA 203, PH 201]

A detailed development of the first and second Law as applied to an open and closed system in steady and unsteady flow. Thermodynamic properties of pure substances, condensible vapors and the perfect gas. The concept of entropy, reversibility, irreversibility, and availability.

ME 342 **Thermodynamics II** **(3-0)3**
[ME 341]

The application of the laws of thermodynamics to energy conversion cycles for vapors and perfect gases. Thermodynamic relations, mixtures and solutions, phase and chemical equilibrium, and the thermodynamics of compressible flow.

ME 344 **Heat and Power** **(3-0)3**
[MA 104, PH 102]
[Primarily for IM students]

The principles of thermodynamics, properties of steam and its utilization in manufacturing processes, and a brief treatment of power plants and heating and ventilating equipment.

ME 347 **Elements of Thermodynamics and Heat Transfer** **(3-0)3**
[MA 203, PH 201]
[Primarily for CE and EE students]

A study of the first and second law of thermodynamics with application to systems and changes of state. Heat transfer by conduction, convection, and radiation. Steady and unsteady cases.

ME 351 **Measurement** **(3-0)3**
[EE 212, MA 204]

A study of the basic concepts and principles associated with the use and design of instruments for measuring various physical quantities. Mode of operation, accuracy. Statistical methods for evaluation of reliability of measurements. The role of measurements in control systems.

ME 372 **Strength of Materials** **(3-0)3**
[ME 315]
[Primarily for IM students]

The fundamentals of stress, including such topics as torsion, axial force, shear, bending moment, combined stresses.

ME 373 **Plastics Mold and Die Design** **(2-2)3**
[Primarily for PL students]

The fundamentals and basic principles of mold and die design for injection, compression, transfer, thermoforming and extrusion processes. Design considerations will include metal

selection, runner and gate construction for the various polymeric materials. Laboratory will consist of actual design of a mold or die, with emphasis on relative drafting.

ME 376 Plastics Mold Design and Construction (0-3)1
[ME 271 and ME 373]
[Primarily for PL students]

A study of the basic types of plastic molding machines along with the basic principles of mold design and construction. The design and construction of simple molds is carried out by actual laboratory work for use on the machines in the Department of Plastics Technology.

ME 377 Elements of Materials Science (2-0)2
[Primarily for IM and TE students]

Introduction to mechanical, electrical, thermal, and chemical properties of materials. Primary and secondary interatomic attractive forces, crystal structures, deformation of metals, strain hardening and solid solutions. Properties of ceramic phases and organic materials are considered together with reaction rates, corrosion, and stability of materials under service stresses.

ME 382 Fluid Mechanics I (3-0)3
[MA 301, MA 302 concurrently]

Rigorous mathematical development of basic fluid mechanical relations; continuity, momentum, and energy equations. Lagrangian vs. Eulerian approaches. Applications to inviscid and viscous, incompressible flows. Similarity and dimensional analysis. Boundary layer concepts and mathematical description. Fundamentals of turbulence. Introduction to low speed aerodynamics. Development of angular momentum principles and their application to turbomachinery.

ME 384 Fluid Mechanics (3-0)3
[MA 203, PH 201]
[Primarily for TE students]

Fluid statics; pressure and fluid forces, buoyant forces. Flow of "ideal" fluids. Equations of continuity and momentum. Potential flow. Dimensional analysis; π -theorem. Flow of "real" fluids; viscous effects, boundary layer, drag, pipe networks, open channel flow. Fluid measurements, and turbomachinery.

ME 415 Mechanical Engineering Laboratory III (0-3)1
[ME 342, ME 382, ME 443 concurrently]

Continuation of ME 314. Experiments designed to demonstrate principles of thermodynamics, fluid mechanics, and heat transfer.

ME 416 Senior Project (0-3)1
[Senior Standing]

Direct engineering experience in planning, executing, and reporting of an individual project selected by the student in consultation with the M.E. Staff Members.

ME 417 Dynamics II (3-0)3
[MA 302, ME 309]

Work-energy relation. Conservative force fields. Impulse and Momentum. Conservation of energy. Generalized coordinates and Lagragne's Equations. Vibrations of single and multiple degree of freedom systems.

ME 419 Nondestructive Evaluation Techniques (3-0)3
[Senior Standing]

The nondestructive evaluation of materials and processes by penetrating radiations, such as sonic, magnetic, thermal, and electrical, and the abilities and limitations of each. Particular emphasis is placed upon the analysis and correlation of the interactions of these energy forms with material properties and processes. Flaw detection; process improvement, control, and monitoring; and measurement of mechanical, physical, chemical, and metallurgical properties.

ME 421 Machine Design (2-3)3
[ME 215, ME 216]
[Primarily for TE students]

The application of the principles of mechanics to the design of typical machine elements, such as shafts, springs, screws, belts, clutches, brakes, bearings, gears, and cams. Theories of failure and methods of establishing working stress levels are considered.

ME 422 Machine Design II (2-3)3
[ME 320]

A continuation of ME 320. Laboratory problems emphasize

aspects of the overall design process; the use of the layout tool in machine design; the compromise between theoretical and practical considerations; optimum design criteria.

ME 428 Kinematic Mechanism Synthesis (3-0)3
[ME 309]

Mechanism concepts, symbolic notations, coupler curves, and the Gruebler criterion. Planar linkage synthesis by geometric methods, synthesis of function generators and dwell linkages, and the Euler-Savory equation. Analytic methods of synthesis, Freudenstein's method, kinematics of spatial mechanisms, matrix representation of rotation, and general matrix methods of analysis.

ME 430 Design of Mechanical Systems (3-0)3
[ME 320, ME 417, ME 497]

Solution by the student of problems involving the analysis and synthesis of mechanical engineering problems with primary emphasis on the area of applied mechanics and controls. A minimum of one major design project is completed under the supervision of M.E. staff members. Consideration of the design process including problem definition, solution synthesis, design analysis, trade off and optimization.

ME 441 Statistical Thermodynamics (3-0)3
[MA 302, ME 342]

Statistical mechanics for systems of independent particles. Quantum mechanics for particle motion. Thermodynamic properties of monatomic gases and solids, and polyatomic gases. Irreversible processes, Onsager relations.

ME 442 Design of Thermal Systems (3-0)3
[ME 443, ME 497]

Solution by the student of problems involving the analysis and synthesis of mechanical engineering problems with primary emphasis on the area of thermal-transport science and controls. A minimum of one major design project is completed under the supervision of M.E. Staff Members. Consideration of the design process including problem definition, solution synthesis, design analysis, trade off and optimization.

ME 443 Heat Transfer (3-0)3
[MA 302, ME 341, and ME 382]

Mathematical theory and applications of steady and tran-

sient heat conduction in solids. Heat transfer in convection and application to heat exchangers. Hydrodynamic and thermal boundary layer theory. Development of thermal radiation theory and its application to heat exchange with and without absorbing gases. Combined heat transfer by conduction, and radiation.

ME 445 Heat Transfer (3-0)3
[MA 204, ME 341 and ME 384]
[Primarily for TE students]

General heat transfer fundamentals and methods of analysis for problems involving conduction through solids during both steady state and transient conditions, heat exchange by thermal radiation, free convection, forced convection, finned surfaces, tube bundles and heat exchangers.

ME 446 Energy Conversion (3-0)3
[EE 212, MA 302, ME 441 and ME 443]

Concepts of thermodynamics pertaining to energy conversion. Solid-state phenomena involved in conversion processes; energy forms, equations of state, and energy fields. Conversion methods using thermal cycles, thermoelectric devices, thermionic devices, magnetohydrodynamic generators, fuel cells, and photoelectric principles. Introduction to electromechanical energy converters. The concept of efficiency and losses in these systems.

ME 452 Applications of Numerical Analysis (3-0)3
[MA 360; Senior Standing]

Iterative solutions of transcendental equations. Rapidity of convergence and estimate of error. Method of least squares. Extrapolation to the limit. Numerical differentiation. Numerical and Gaussian quadrature. Romberg integration. Numerical solution of first order, ordinary differential equations. Predictor and corrector formulas. Finite difference solutions of second order, partial differential equations. Applications to problems in fluid mechanics, solid mechanics, and heat transfer. Solutions set up and carried out on digital computer.

ME 462 Engineering Analysis (3-0)3
[Senior Standing]

A study of the methods used in engineering analysis with emphasis on the basic types of underlying mathematics. Prob-

lem examples include both discrete and continuous systems encountered in the fields of solid mechanics, fluid mechanics, heat transfer, and electrical networks.

ME 468 Fluid Machinery (3-0)3
[ME 382]

Review of thermodynamic principles, incompressible and compressible fluid mechanics. Classical turbine theory, (one-dimensional treatment). Cascade mechanics. Thin air-foil theory. Flow in three dimensions. Loss mechanism; boundary layers; cavitation.

ME 472 Experimental Stress Analysis (2-3)3
[ME 220]

An introduction to the Theory of Elasticity; the determination of stress and strain distributions by experimental methods. Photoelasticity, birefringent coatings, brittle coating, analogies, strain gage applications, rosette analysis.

ME 473 Mechanics of Materials II (3-0)3
[MA 302, ME 220]

The state of stress at a point; theories of failure by yielding; energy methods; inelastic buckling; buckling of tubes; shear center; unsymmetrical bending; curved flexural members; torsional resistance in non-circular sections.

ME 475 Physical Metallurgy (3-0)3
[ME 296]

A detailed study of the theories discussed in materials science as they apply more specifically to metals. These include dislocation and slip phenomena, recrystallization and grain growth, diffusion, precipitation hardening, solidification of metals, martensite reactions, X-Ray diffraction and fracture.

ME 482 Fluid Mechanics II (3-0)3
[ME 382]

Extension of basic equations of motion and energy to inviscid, compressible fluids. Acoustic equations. One-dimensional, steady flows with area change. Fanno and Rayleigh flows. Normal and oblique shocks. Crocco's theorem. Prandtl-Meyer expansion. General linerarized theory with applications. Method of characteristics. Introduction to real gas effects.

ME 488 **Environmental Conditioning** **(3-0)3**
[ME 443]

The control of thermal environment within enclosed spaces including transfer of heat and work energy. Refrigeration cycles, heating, humidification, dehumidification and mixtures. Design of conditioned spaces.

ME 493 or 494 **Industrial Instrumentation** **(2-0)2**
[MA 104, PH 102]
[Primarily for PL students]

Modern methods of measurement and control of the more common process variables, such as temperature, pressure, liquid level, and fluid flow; response characteristics of mechanical, electric, and electronic instruments; modes of control; associated mechanical and electrical mechanisms; characteristics of final control elements; closed-loop control systems; and process characteristics and their effects upon the selection of the correct mode of control.

ME 495 **Electromechanical Engineering** **(3-0)3**
[EE 212, MA 204]
[Primarily for TE students]

Characteristics of electromechanical transducers and their associated circuitry as employed in the measurement of acceleration, velocity, displacement, stress, strain, thickness, mass, weight, frequency, time, and level of intensity.

ME 497 **Automatic Control Systems I** **(3-0)3**
[EE 212, MA 302, ME 351]

Concept of open and feedback control systems. Use of block diagram and transfer functions for system representation. Analytical techniques for evaluation of system performance, transient and steady state response, stability and compensation. Consideration of hydraulic, pneumatic and electromechanical control systems.

ME 498 **Automatic Control Systems II** **(3-0)3**
[ME 497]

The design, analysis and application of hydraulic, pneumatic and electromechanical control systems; regulators and servomechanisms; multiple loop systems. System improvement; treatment of nonlinear systems.

METEOROLOGY

MY 203 Elementary Meteorology (3-0)3
[MA 104, PH 102]

Distribution of temperature, pressure, water vapor and velocity. Cyclones, anticyclones, air masses and fronts. Formation and distribution of fog, clouds, precipitation, thunderstorms and tornadoes. Elements of atmospheric thermodynamics and hydrodynamics.

MY 301 Atmospheric Dynamics (3-0)3
[MY 203, MA 204]

Thermodynamics of dry air, water vapor and moist air. Hydrostatic equilibrium and its stability. The equations of motion for the atmosphere.

MY 302 Atmospheric Dynamics (3-0)3
[MY 301]

Linear velocity field and thermal circulation. Steady state motion. Eddy viscosity. Elements of numerical weather prediction and general circulation theory.

MY 307 Tropical Meteorology (3-0)3
[MY 203]

An introduction to tropical meteorology. Distribution of temperature, pressure, water vapor and velocity. Observations from aircraft, satellites and radar. Analysis of tropical data. Air sea interaction; convection and clouds. The trade wind region and intertropical convergence zone. Easterly waves and tropical storms.

MY 308 Synoptic Meteorology (2-3)3
[MY 301]

An introduction to weather analysis: coding and plotting of data and elementary methods of analysis. Interpretation of current maps sent on the National Weather Facsimile Network.

MY 403 Physical Meteorology (3-0)3
[MY 302]

Solar and terrestrial radiation processes and the heat balance of the atmosphere: fundamentals of radiation theory; ra-

diative transfer processes in the atmosphere. Atmospheric condensation processes: nucleation theory and the growth of water drop and ice crystals by condensation, sublimation and accretion. Meteorological aspects of air pollution.

MY 405 Individual Studies (1-0)1
[MY 302]

Research or literature on specific meteorological or climatological problems and submission of a written paper to the department.

MY 406 Individual Studies (1-0)1
[MY 302]

Research or literature on specific meteorological or climatological problems and submission of a written paper to the department.

MY 411 Oceanography (2-0)2
[MY 302]

Physical properties of sea water. Distribution of pressure, temperature and salinity. Heat budget of the oceans. The wind-driven currents.

MY 412 Oceanography (2-0)2
[MY 411]

Oceanic dynamics: theories of the wind-driven and thermal currents; transfer processes; waves and tides; theories of general circulation in the oceans.

MY 414 Mathematical Methods in Meteorology (3-0)3
[MY 302]

Survey of mathematical techniques used in the solution of various basic meteorological problems. Initial and boundary value problems in atmospheric dynamics. Numerical and statistical methods of forecasting.

MY 421 Analysis and Forecasting (1-6)3
[MY 302, MY 308]

Analysis of recent synoptic data. Use of concepts of advection, thickness change, geostrophic vorticity change, vertical motion and Sutcliffe development in analysis and forecasting. Vorticity and primitive equation models in forecasting.

MY 422 Analysis and Forecasting (1-6)3
[MY 421]

Practice in forecasting temperature, precipitation, wind speed and direction, fog, smoke, turbulence and icing, using climatology, kinematics and dynamics. Use of verification procedures.

MY 431 Geophysical Fluid Dynamics (2-0)2
[MY 302]

Fundamentals of geophysical fluid dynamics. Wave motions in the atmosphere and oceans. The stability problem. Convection.

MY 432 Geophysical Fluid Dynamics (2-0)2
[MY 431]

Models of large-scale circulation in the atmosphere and oceans. Theories of meso-scale and small-scale circulations in the atmosphere.

NUCLEAR ENGINEERING

NU 201-202 Introduction to Nuclear Engineering (3-0) (3-0)6

A general review of atomic and nuclear structure, the properties of nuclear radiations, and radiation measurement. Nuclear forces and nuclear structure. Neutrons and fission. Utilization of nuclear energy. Nuclear reactors. Fuels and fuel reprocessing. Health Physics and radiation protection. Accelerators. Fusion reactions and the long-term energy picture.

NU 305-306 Nuclear Instrumentation (2-4) (2-4)8

The first semester lectures cover the fundamentals of circuit theory as applied to pulse circuits, and the laboratory covers the construction, testing, and evaluation of component circuits and instruments. The second semester lectures are devoted to the design and operating characteristics of detectors and their use with electrometers, ratemeters, scalers, and pulse height analyzers. The laboratory work of the second semester is devoted mainly to the characteristics of detectors and associated measuring circuits.

NU 405-406 Nuclear Reactor Engineering (3-0) (3-0)6

Neutrons, cross-sections and fission. Steady state and the criticality condition. Reflected, homogeneous and heterogeneous reactors. Fast reactors. Reactor control. Kinetics and reactivity effects. Control systems and instruments. Coolants and moderators. Fuels. Reactor Operations.

NU 493 Advanced Nuclear Laboratory (0-6)3

Characteristics of tubes and transistors. Construction and operating characteristics of amplifiers and oscillators. Principles of feedback and servo system. Construction of pulse and digital circuits; binary circuits, mono and astable; trigger, coincidence and anti coincidence circuits.

NU 494 Advanced Nuclear Laboratory (0-6)3

Neutron activation experiments. Szilard Chalmer experiment. Measurements of slowing down lengths, diffusion lengths. Fermi Age. Effect of poisons in moderators as well as insertion of control rods. Experiments on reactor simulator including period measurements and effects of poison. Experiments on accelerator and reactor.

NU 495 Special Nuclear Problems (3-0)3
[Permission of Head of Department and Instructor]

Special problems in nuclear engineering assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

NU 505-506 Reactor Physics (3-0) (3-0)6

NU 505. Nuclear Reactions induced by neutrons: cross sections, fission; diffusion and slowing down of neutrons; Diffusion, Fermi Age and multi group treatment of unreflected and reflected homogeneous reactors, reactor design parameters.

NU 506. Reactor physics problems relating to the operation and kinetics of a nuclear reactor. Effect of poisoning, and temperature on design criteria; excess reactivity; elementary reactor kinetics, perturbation theory and control rod theory. Introduction to transport theory.

NU 507-508 Reactor Engineering (3-0) (3-0)6

Analysis of fluid dynamics, heat transfer and thermal stresses as they influence the performance of a nuclear power

reactor. The relation of such considerations to the core physics design. Power Plant Thermodynamics; energy production and distribution.

PAPER ENGINEERING

PA 301 Engineering Analysis of Pulp Systems (3-3)4
[CN 204, PA 307 taken concurrently]

Lectures and problems concerned with the engineering, design and technology of pulp manufacturing by commercial processes. Discussion of bleaching chemistry and the use of secondary fibers. Laboratory projects designed to illustrate problems involved in processing of pulp TAPPI Standard methods used in various project work.

PA 302 Engineering Analysis of Paper Systems (3-3)4
[PA 301]

Discussion and study of engineering, design and economics of commercial methods of production of papers. Stock preparation; changes in physical and chemical properties of pulps; filling and loading of fibers; sizing, coloring and other additives. Material and energy relationships of various processes. Laboratory projects designed to illustrate principles expounded in lectures.

PA 307 Physical Testing and Data Analysis (3-0)3

Fundamentals of the mechanical and optical testing of paper and allied products. Discussion of engineering mechanics involved in various testing procedures. Statistical analysis of testing. Structure of materials revealed by physical tests.

PA 403 Engineering Analysis of Converting (3-0)3
[PA 302]

Lectures and problems concerned with the engineering, design, technology and economics of paper and paperboard converting processes. Rheology of coating materials and engineering properties of materials used for coatings. Mechanical, coating, impregnating, laminating and printing processes discussed in detail.

PA 405 Paper Converting Laboratory I (0-3)1
[PA 403 taken concurrently]

Development of converting techniques used with paper

and paperboard. Use of Tappi Methods of evaluation. Emphasis is placed on colloidal and rheological properties of materials used in coating. Detailed written and oral reports.

PA 407 Paper Problems (2-0)2
[PA 302, PA 307]

Mathematical analysis of various processes encountered in the pulp and paper industry, using material and energy balances. Application of chemical engineering principles applied to various operations.

PA 408 Paper Converting Laboratory II (0-3)1
[PA 405]

Special converting problems are studied in detail. Use of more specialized testing methods to evaluation coatings and other paper and paperboard converted products. Special emphasis is placed on the preparation of special converted products and the testing thereof. Oral and written reports required.

PA 410 Analysis of Paper Processing (2-0)2
[PA 302]

Discussion of the variables and factors involved in the formation of the paper web. Consideration given to fiber flocculation and orientation and to headbox design.

PA 419 or PA 420 Special Senior Projects Credits to be arranged

Original research projects primarily in the field of paper engineering, supervised by a staff member. Reports required on work done.

PA 503-504 Advanced Converting Processes (3-0) (3-0)6
[PA 403, PA 408]

Specific converting processes. Analysis of coating processes (water- and solvent-based), extrusion coatings and hot melt coating. Latest techniques used by the converting industry, involving mechanical and chemical operations. Engineering analysis of processes. Oral and written reports and plant visits.

PA 506 New Techniques in the Paper Industry (3-0)3
[Approval of instructor]

Lectures and discussion of new developments in engineer-

ing, design and application of physical and chemical principles in the manufacture of paper and paper products. Economic comparisons of new processes. Plant visits. Oral and written reports.

PA 509 or PA 510 — Economics of the Paper Industry (2-0)2
[Approval of instructor]

An evaluation of the paper industry from an economic viewpoint. Examination of costs and availability of different raw materials, additives and finishing materials. Analysis of competitive position of the paper industry and its products. Evaluation of foreign competition.

PA 512 — Advanced Fiber Processing (3-0)3
[PA 302]

A study of fiber properties as related to fiber processing. Treatment of various theories of fiber processing. Discussion of mechanical treatments of fibers on the wet and dry properties of papers made from these fibers.

PHYSICS

PH 101 — Physics (4-1)4

Mechanics: kinetics; dynamics — inertia, mass, momentum, force, impulse, application of Newton's laws, inertial and noninertical frames of reference.

PH 102 — Physics (4-2)4
[PH 101 or equivalent]

Work, energy, rotational kinematics and dynamics, angular momentum, gravitation, elasticity, and simple harmonic motion. Temperature, ideal Gases, kinetic theory, thermal properties of solid and liquids, 1 and 2nd law of thermodynamics, Carnot cycle, entropy.

PH 201 — Physics (4-2)4
[PH 102]

Elements of Electricity: electrostatics, fields, flux, Coulomb's law, electric potential, Ampere's Law, Faraday's Law and applications. Development of the lumped parameter circuit. Displacement current. Geometrical Optics.

PH 202 **Physics** **(4-2)4**
[PH 201]

Acoustical and optical wave phenomena, such as beats, Doppler Effect, reflection, refraction, interference, and diffraction; polarization; and spectra. Introduction to modern physics, atomic view of matter, Bohr theory of the atom, wave-particle duality.

PH 207 **Mathematical Techniques of Physics I** **(4-0)4**
[MA 108]

Techniques of approximate solutions of physical problems. Techniques of exact solutions of physical problems with applications to electrostatics, magnetostatics, and hydrodynamics, with appropriate mathematical background.

PH 208 **Mathematical Techniques of Physics II** **(4-0)4**
[PH 207]

Techniques of solutions of differential equations used in physics and engineering problems; in particular solution of the wave equation in bounded and unbounded media, with applications to electromagnetic phenomena and propagation of heat and sound.

PH 209 **Physics** **(4-0)4**
[PH 102]
[For physics majors only]

Same basic curriculum as in PH 201 with greater emphasis on field theory aspects. In addition, development of Maxwell's equations in integral differential form. Simple solutions and applications.

PH 210 **Physics** **(4-0)4**
[PH 209]
[For physics majors only]

Acoustical and optical Wave phenomena; reflection, refraction, interference, diffraction, polarization, Doppler Effect: group velocity Fourier analysis. Introduction to special theory of relativity; an atomic view of matter. Breakdown of classical mechanics.

PH 293-294 **Experimental Physics** **(2-6) (2-6)8**
[Permission of Instructor]

Physical phenomena and methods used to observe and

measure them. Elements of Circuit theory required for an understanding of measurements made with AC and DC instruments. Difficulties, limitations and interpretation of measurements. Demonstration of pertinent physical phenomena.

PH 311-312 Intermediate Mechanics (3-0) (3-0)6
[PH 208]

Kinematics of a single particle, and analysis of Newton's laws of motion, the mechanics of a single particle in one and in more than one dimension, conservative and non-conservative forces, central forces, the mechanics of systems of particles from the points of view of Newton, Lagrange, and Hamilton; generalized coordinates and moments, the Hamiltonian function, rotating rigid bodies, moments and products of inertia, principal axes, the theory of small oscillations, normal modes of vibration, and the vibrating string.

PH 335 Modern Physics (3-0)3
[PH 208, PH 210]

Black body radiation, Rayleigh, Jean's Law, Planck's law, photoelectric effect, X-rays, Compton effect, wave particle duality, DeBroglie waves, wave pockets, atomic structure, Rutherford model and Rutherford scattering. Bohr Model, Franck-Hertz experiments, correspondence principle, Bohr-Sommerfield model. Introduction to Wave Mechanics and quantum numbers. Pauli exclusion principle, and vector model of the atom.

PH 336 Modern Physics (3-0)3
[PH 335]

Elementary application of wave and quantum mechanics to natural phenomena. Electron spin, spectroscopic nomenclature. Zeeman effect. Stern Gerlach experiment. Applications to solid state and introduction to nuclear physics.

PH 353-354 Electromagnetic Theory (3-0) (3-0)6
[PH 208, PH 209]

The theory of electromagnetic fields using vector analysis and Maxwell's equations. Static electric and magnetic fields in dielectrics, conductors, and ferromagnetic materials; the scalar and vector potentials and time-varying fields; and the special theory of relativity. Plane waves in dielectrics and conductors, the Poynting vector, Fresnel's equations, and waveguides; radiation from antennas and accelerated charges; polarization, interference, and diffraction; and receivers.

PH 363 Introductory Nuclear Physics (3-0)3
[For students majoring in Nuclear Engineering]

Natural radioactivity; the Bateman equations; isotopic abundance; induced activity; the energetics of nuclear reactions; and alpha, beta, and gamma emission.

PH 366 Intermediate Nuclear Physics (3-0)3
[For students majoring in Nuclear Engineering]

The compound nucleus and resonance theory, cross sections, Rutherford scattering, center of mass coordinates, neuton physics, nuclear radii, nuclear stability and forces between nucleons, and nuclear models.

PH 393-394 Advanced Laboratory (1-6) (1-6)6
[Permission of Instructor]

A laboratory course which accompanies the junior and senior courses in the department, and which may serve as a vehicle for undergraduate experimental research in selected fields of physics and for practice in exposition or in teaching.

PH 423 Thermodynamics (3-0)3
[PH 207]

A macroscopic analysis of the behavior of thermodynamic systems including the following topics: thermodynamic equilibrium states, the concept of temperature, the first law of thermodynamics, real and ideal gases, the ideal gas temperature scale, heat engines and refrigerators, the second law of thermodynamics, reversible processes, the Carnot cycle, the Kelvin temperature scale, the concept of entropy and its philosophical significance, pure substances, enthalpy, Helmholtz free energy, Gibbs free energy, Maxwell's relations, the TdS equations, and applications found in modern physics.

PH 424 Introduction to Statistical Mechanics (3-0)3
[PH 312, PH 441, PH 423, MA 484]

A continuance of PH 423, but at a microscopic level and including the following topics: probability theory, the classical statistical mechanics of Gibbs, phase space, phase density, Liouville's theorem, the microcanonical, cononical, and grand canonical ensembles, the partition function, the statistical mechanical interpretation of the thermodynamic functions and laws, modifications required by quantum mechanics, the Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distribution laws, and applications of the theory to ideal gases.

PH 441-442 Introduction to Relativity and Quantum Mechanics (3-0) (3-0)6
[PH 335-336, PH 311-312, PH 353-354, or Permission of Instructor]

Coverance of physical laws, Lorentz transformation, relativistic mechanics, tensor analysis, proper time, Minkowski force, particle collisions, relativistic electrodynamics, field tensor. Experimental basis for interference of particles and the uncertainty principle; postulates of quantum mechanics, operators hermiticity, commutativity, orthogonality of eigenfunctions; first order perturbations of energy levels, harmonic oscillator, free particle, one electron atom, hydrogen fine structure, Pauli principle and atomic shell structure.

PH 461-462 Nuclear Physics (3-0) (3-0)6
[PH 336]

Ionization of matter by charged particles, mass-energy relationships, packing fraction, elementary discussion of properties of a nucleus, radioactive decay, systematics of alpha and beta decay, alpha decay theory, gamma emission, two nucleon systems, nuclear reactions and nuclear structure, and properties of neutrons.

PH 471-472 Solid-State Physics (3-0) (3-0)6
[PH 441-442 taken concurrently]

Crystal structure and X-ray and neutron diffraction; free electron model; band theory of solids; quantum mechanical considerations; lattice energy, lattice vibrations, and infrared absorption; lattice defects; thermal properties of solids; dielectric and magnetic properties; mechanical properties; and semiconductor crystals.

PH 495-496 Special Research Problems (3-0) (3-0)6
[Permission of Head of Department and Instructor]

Special problems in theoretical and experimental physics assigned to the individual student, with emphasis on modern research methods and preparation of results for publication.

PH 505-506 Mathematical Methods of Physics (3-0) (3-0)6

Elements of complex variables; Fourier and other transforms; ordinary differential equations and their classification, and Frobenius and other methods of solution; partial differen-

tial equations and their classification; boundary value problems, Sturm-Liouville theory and eigenvalues; vector spaces; Green's functions and integral equations of the first and second kind; and introduction to group theory.

PH 507 High-Energy Physics (3-0)3
[PH 516]

A survey designed for the nonspecialist. Elements of relativistic scattering theory, the quantum numbers and conservation laws of high-energy physics, strong and weak interactions, and an introduction to the theory of unitary symmetry and its consequences.

PH 511-512 Classical Mechanics (3-0) (3-0)6
[PH 312]

An analysis of the mechanics of systems of particles from the points of view principally of Newton, Lagrange, and Hamilton, including the following topics: Newton's laws, conservative and non-conservative forces, holonomic and nonholonomic constraints, Lagrange's equations, Hamilton's principle, orthogonal transformations, the motion of rigid bodies, rotating frames of reference, the rotation of a symmetrical rigid body, Hamilton's equations, the principle of least action, canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action and angle variables, and a comparison between classical mechanics and geometrical optics.

PH 515-516 Quantum Mechanics (3-0) (3-0)6
[PH 441, PH 511-512 taken concurrently]

Wave pockets and free particle motion, the wave function and the Schrodinger equation, the linear harmonic oscillator, the WKB approximation, central forces and angular momentum, spin, and time-dependent and independent peturbation theory. Scattering theory.

PH 517-518 Advanced Quantum Mechanics (3-0) (3-0)6
[PH 516]

The formal theory of scattering. The Klein-Gordon and Dirac equations, the Foldy-Wouthuysen transformation, elements of covariant perturbation theory based on Feynman's propagator approach, and renormalization theory. Secon quantization and canonical commutation rules, the connection between spin and statistics, the TCP theorem, and selected topics in strong and weak interactions.

PH 521-522 Statistical Mechanics (3-0) (3-0)6
[PH 424]

The classical statistical mechanics of Gibbs and Darwin-Fowler, the quantum statistical mechanics of Fermi-Dirac and Bose-Einstein, and applications to thermodynamics, solid-state physics, and nuclear physics.

PH 557-558 Electricity and Magnetism (3-0) (3-0)6
[PH 208, PH 353-354, or Permission of Instructor]

Electrostatics and magnetostatics with special attention to boundary-value problems. Quasistatic fields and displacement currents, Maxwell's equations, the Special Theory of Relativity, Lienard-Weichert potentials, and radiation from an accelerated charge. Waveguides, scattering, and applications to the problems of modern-day physics.

PH 561-562 Nuclear Physics (3-0) (3-0)6
[PH 462]

Stationary states of nuclei, nuclear charge radius, mass, moments, parity, and statistics; theory of alpha, beta, and gamma decay; fission reactions induced by charged particles, gamma rays, and neutrons; nuclear forces and nuclear models; and fast neutron physics.

PH 573-574 Quantum Theory of Solids (3-0) (3-0)6
[Permission of Instructor]

Acoustic and optical phonons; plasmons; the Hartree-Fock approximation; many-body theory; electron-phonon interactions; the band theory of solids; metals; semiconductors; transport theory; neutron diffraction; superconductivity; magnetism; and magnetic resonances.

PH 575-576 Neutral Particle Transport (3-0) (3-0)6

Boltzmann and intergral transport equations, Spherical Harmonic, and variational methods. Correction to diffusion theory. Special methods of solving transport equations. Adjoint functions. Applications.

PH 583-584 General Theory of Relativity (3-0) (3-0)6
[Prerequisite: Knowledge of Special Relativity]

Review of Newtonian gravitational theory and special relativity. Weak and strong principles of equivalence. Tensor analy-

sis in Riemann spaces. Einstein's equations for the gravitational field. Classic tests of Einstein's theory: spherically symmetric solutions. Gravitational field theory, and the canonical analysis of general relativity.

PH 593-594 Graduate Laboratory [Permission of Instructor] **Credits to be arranged**

A laboratory course designed to acquaint the graduate student with the methods and techniques of modern experimental physics.

PH 942 Physics (3-2)4

Elements of electricity and magnetism: Coulomb's law, fields, Gauss' law, potential, current, dc circuits, magnetic fields and forces, induced emf, ac circuits.

PLASTICS TECHNOLOGY

PL 201-202 Introduction to Polymeric Materials (2-0) (2-0)4

A descriptive subject to acquaint the student with plastics as a class of materials. The history, definitions, classes, properties, and applications of plastics.

PL 301-302 PLASTICS TECHNOLOGY I AND II (2-2) (2-2)6
[PL 201 or Permission of Instructor]

Analysis of additives including stabilizers, plasticizers, biocides, release agents, flame retardants, colorants, and foaming agents as well as modifiers and reinforcing agents. Discussion of compounding techniques and the evaluation and development of typical plastics molding compounds. Survey of materials for reinforced plastics and composites, film and sheeting, adhesives, and non-plastics applications of polymers. Laboratory instruction in the processing and fabrication of plastics materials.

PL 401-402 Plastics Technology III and IV (2-2) (2-2)6
[PL 301-302]

Application of plastics as engineering materials. Product, equipment, and mold design. Correlation of composition, processing, and fabrication with product design and applications. Continuation of laboratory instruction in processing, molding, and fabrication.

PL 403-404 Properties of Polymers (2-2) (2-2)6
[Open to seniors only]

Correlation of composition and structure with important engineering properties of plastics; environmental conditioning and effects of types of loading in evaluation of plastics materials; the theory of testing; critical examination of testing techniques, equipment, and standard ASTM methods of evaluating mechanical, thermal, electrical, and optical properties.

PL 406 Polymer Structure (3-0)3

The fundamental relationships between molecular structure, properties, and end-use applications of plastics materials will be explored in detail. Molecular structural features include chemical composition, molecular size and flexibility, intermolecular order and bonding, and supermolecular structure. Properties include processability; mechanical, acoustic, thermal, electrical, optical, chemical properties; price, and balance of properties. Applications include rigid solids, flexible solids, foams, films, and non-plastics applications. May be taken for graduate credit.

PL 407 Plastics Industry Organization (3-0)3

Economics of producing plastics raw materials and converting them into end products, from research and development to plant construction, operation, and marketing. Market analysis of plastics production, processing, and consumer patterns; commercial development, sales, and technical service. Organization of the plastics industry for research and development, specialty and commodity production, profit, and growth. May be taken for graduate credit.

PL 409-410 Senior Research in Plastics (1-6) (1-6)6

Individual research projects in plastics chemistry properties, processing, products, and industry organization. Students will review the existing literature, obtain materials and equipment, plan and carry out research programs, and submit final reports for publication.

PL 411-412 Plastics Seminar (1-0) (1-0)2
[Open to seniors only]

Informal discussions, based on literature study conducted by the individual, of topics in, or related to, plastics technology.

RADIOLOGICAL SCIENCES

RS 401 Principles of Radiation Safety and Control (3-0)3

Introduction to radiation protection, including radiation sources, radiation dose and dose measurement, radiation exposure, radiation protection techniques, monitoring methods and instruments, contamination control and waste storage, facility design, hazards analysis, and applied health physics techniques for the safe handling and control of radioactive material.

RS 422 Environmental Radiation and Nuclear Site Criteria (3-0)3

Sources of radioactive waste and waste treatment. Internal dosimetry, maximum permissible concentrations. Distribution of radioactivity in the environment, the significance of releases to the air, aquatic and terrestrial ecosystems. Design and operation of environmental surveillance programs around nuclear facilities. Reactor site criteria, licensing, regulations, credible accidents, meteorological considerations, normal and abnormal operations.

RS 441 Radioisotope Techniques (3-3)4

A course for students and staff designed to acquaint them with the theory and use of radioisotopes and the principles and operation of radiation counting systems. Integrated into both laboratory and lecture sessions are topics related to biological effects of radiation exposure, safe use of radiation sources, radiation protection techniques and procedures, and design of radiation facilities.

RS 501 Radiation Physics and Shielding Design (3-0)3

Interaction of neutrons, gamma rays and charged particles with matter. Buildup factors, shielding design factors in reactors and accelerators. Application of transport theory to penetration of shields by particles.

RS 503 Introduction to Radiation Chemistry (3-0)3

A study of the interaction of all types of ionizing radiation with matter and the resulting radiation-induced chemical reactions; excitation, ionization, and free radical formation and recombination.

SS 223 The United States: 1865-1912 (3-0)3

With the unit approach, a study of the following: Political development from Reconstruction to the New Freedom, the rise of labor and industry after 1870, the rise of the West and its influence, diplomacy before World War I, and the social and cultural development of the American people.

Collateral readings will be required for each topic.

SS 224 The United States: 1912 to the Present (3-0)3

[No prerequisite, but SS 223 is recommended as background]

Continuing the topical analysis of SS 223, a study will be made of the political philosophies from Wilson to Johnson, the industrial problems of the 20th Century, the transition from isolation to free world leadership, economic cycles, the impact of science, and current issues.

Collateral readings will be required for each topic.

SS 225 Europe: 1789-1914 (3-0)3

A study of those events which have played an important part in shaping the modern world, with emphasis upon such topics as the French Revolution, the Industrial Revolution, social and political reforms, the rise of nationalism and imperialism, and the background of World War I.

SS 277 Europe: 1914-1939 (3-0)3

A study of the quarter-century in which the "Great War" and the postwar settlements and realignments created a new Europe and set the stage for World War II. Emphasis is given to the rise of totalitarianism and the changing power patterns in Continental Europe and the world at large.

SS 228 Europe: 1939 to the Present (3-0)3

A survey of the major events of World War II and the key factors in the postwar alignments. Particular attention is given to the roles of Soviet Russia and the United States, the effects of regionalism and internationalism, the decline of imperialism, and the economic, political, and social developments in the major nations in the period.

SS 301 Government of The United States (3-0)3

A study of the political structure of the national government and the most crucial problems, domestic and foreign, that it is facing today. Emphasis is given to the manner in which the American federal government is confronting these problems and their influence on American society.

SS 302 Conduct and Control of Foreign Policy (3-0)3

Consideration of the ways in which a state's conduct of its foreign policy affects and is affected by both the substance and the processes of its domestic politics. Primary consideration is given to the United States and the principal nations of Western Europe.

SS 303 or 304 Psychology (3-0)3

An introduction to the basic principles of human behavior. The major areas covered include the origins and development of psychology as a science, the stages of human development, motivation and emotion, sensing and perceiving, the nature and management of learning, testing ability and intelligence, and neuroses and psychoses.

SS 305 or 306 Sociology (3-0)3

The principles of Sociology, including the development of Man, culture, culture and personality, social organization and structure, groups and group life, social relations, collective behavior, social change, and social institutions.

SS 307 Seminar in Sociology (3-0)3

[Limited to upperclassmen. Approval of Instructor required.]

Designed to assist the advanced student with the proper sociological concepts and insights as they apply to the social settings in business and industry. The core objective is the development — through the case method — of the balance between skill and knowledge and their application in sound technical and administrative decisions affecting individuals and groups within organizations.

SS 371 or 372 American Civilization to 1865 (3-0)3

A study of the development of national consciousness in the United States. Emphasis is given to the economic, political,

and social which were causing the simultaneous growth of the sectionalism that led to the Civil War.

SS 403 Psychological Warfare (3-0)3

Inquiry into the role of psychological warfare in modern foreign policy. Special attention is given to such activities as economic aid, technical assistance, military missions, cultural exchanges, and information services of various types.

SS 459 World Politics: The Central Problem of War (3-0)3

War as the central phenomenon of world politics — Its causes and functions in theory and in history; its effects on the individual and society; efforts to control it; and the ethical problems that it raises.

SS 471 The United States in World Politics (3-0)3

The backgrounds of American foreign policy and the various circumstances and conditions under which these principles have been applied by the United States are examined through case studies.

SS 472 Defense Policy (3-0)3

A study of the relationship of force and foreign policy in the thermonuclear age. Discussions cover organization and policy-making, military policy and strategy, and the substance of national security.

SS 477 Russia: The Empire (3-0)3

A study of the history of the Empire of the Tsars with special emphasis upon the economic, political, and social problems that led to the Revolution of 1917.

SS 478 Russia: The Soviet Union (3-0)3

A study of the history of the U. S. S. R. from 1917 to the present. The course will be divided into three general areas: Establishment of the Soviet state; the Stalinist period; and current domestic and foreign problems.

SS 479 The Far East Since 1842 (3-0)3

Nasic historical and cultural backgrounds of the peoples of East Asia surveyed as a preface to the study of the develop-

ment of mainland and island states. Emphasis is given to American and European interest, policies, and relationships with China, Japan, and Korea.

SS 480 Modern China: 1644 to the Present (3-0)3

A study of developments in China's economic, political, and social evolution from the Manchu conquest to the Maoism of the 1960's. Emphasis will be given to China's foreign relations under the Manchus, during the "Nationalist" period, and since the advent of the Communist regime in 1949, as well as to "Red China's" role in Asian and global affairs today.

SS 481 or 482 The Greeks and Western Civilization (3-0)3

An examination of the contributions of the Greeks to our culture. The influences of Greek thought, art, and politics are studied in selected readings and discussions in seminar meetings.

SS 483 Political and Social Thought: The Greeks and the Romans (3-0)3

Studies in the works of the major writers of political and social philosophy from the origins of the Greek city-state into the decline of the Roman Empire. The relevance of early ideas to modern times will be stressed in class discussions.

SS 484 Political and Social Thought: 400 A. D. - 1600 A. D. (3-0)3

A study of the impact of Christianity on political and social ideas; the relation of ideology to institutions in the feudal period; and medieval ascetism and Renaissance individualism from St. Augustine through Machiavelli.

SS 485 Political and Social Thought: 1600 - 1800 (3-0)3

Puritanism, the Age of Science, and the Enlightenment; ideology from the Wars of Religion through the French Revolution; and the origins of modern conservatism and liberalism.

SS 486 Political and Social Thought: 1800 to the Present (3-0)3

The development of conservatism and liberalism since the

Napoleonic Wars; Socialism, Communism, and Fascism; and the psychoanalytic and behavioral approaches to ideology.

SS 487 American Political Thought to 1865 (3-0)3

A study of those events which have shaped American political thought, with emphasis upon the American Revolution, the Constitution, and the Civil War.

SS 488 American Political Thought Since 1865 (3-0)3

An examination of the evolution of the American political tradition in the modern age, with special attention to the reform movement, the Roosevelt era, and wartime and post-war periods.

SS 492 Twentieth Century Germany (3-0)3

Political development, social and military history, and conflicts of the "-isms" in Germany from the founding of the Empire to West Germany's assumption of a position in the NATO Alliance. Relation of the nation's past to current problems of reunification, international position, and politics are studied though selected readings and discussions in seminar meetings.

SS 495 The Technological Future: The Material Aspects (3-0)3

Lectures and discussions forecasting the completely technologized society of 2000 A. D. The first semester emphasizes the nature of several "futuribles" — the possible futures — from the surprise-free environment to those involving scientific breakthroughs.

SS 496 The Technological Future: The Social and Political Aspects (3-0)3

Lectures and discussions during the second semester emphasize man's adaptation to the vast changes of the future and the probable nature of the future world civilization.

SS 497 or SS 498 Seminar: History or Political Science (3-0)3

[Permission of Instructor]

Independent directed study under the guidance of individual members of the department.

SS 499 **Science and Religion: Science as a Social System** **(3-0)3**

Consideration — through lectures and discussions — of the role of Science as a system of "Communication", in the contemporary sense in which that term is used in sociological, psychological, and communication-science studies. The latter phase of the course will stress in preview the relations between Science and Religion as social systems.

SS 500 **Science and Religion: Religion as a Social System** **(3-0)3**

The course will emphasize the role of Religion as a system of "Communication", in the sense defined in the paragraph above for SS 499. The latter part of the course will emphasize the interconnections, both conflict and cooperation, between Science and Religion.

SS 502 **Afro-American History** **(3-0)3**

An historical study of the patterns of racial relations and the participation of Afro-Americans in the social, economic, political, and cultural life of the United States. The topics covered include the origins and development of the slave system, the Civil War and Reconstruction, urbanization, the Civil Rights movement, and "Black Power."

TEXTILES

TE 212 **Fiber Science** **(3-1)3**
[Given in first semester for graduate students only]

The different fibers and their origin and properties. The effect of molecular arrangement in fibers upon the chemical, physical, and mechanical behavior of the raw material and upon their technological utilization. Polymer structure, order, intermolecular forces, flexibility, and other properties in the light of stress-strain relationships, such as viscoelastic behavior. These and other factors as design elements leading to the prediction of the physical properties of textile systems, as well as the geometry of yarns and fabrics and their behavior characteristics.

TE 264 **Textile Systems I** **(3-1)3**

The preparation into yarn of staple cellulosics and man

made fibers on the cotton system as well as filamentous man made fibers. These are presented analytically in terms of engineering principles or mechanisms concerned with functional use, structural design, and basic geometry of the yarns.

TE 305 Textile Mechanism (3-0)3

A study of the basic principles of kinematics. Topics involved are rolling cylinders and cones, gearing, gear train design, epicyclic gear trains, flexible connectors including stepped pulley and cone design, cam design, linkages, and miscellaneous mechanisms. Available equipment serves as the basis of problems and assignments.

TE 335 Design and Analysis of Woven Structures (3-0)3

The communication of design techniques, construction and analysis of woven substrates as well as fabric identification. The effect of fiber, yarn, weave and texture on the carefully engineered and practical evolvement of the structures is stressed. The principles of yarn geometry and mechanical loom functions are correlated with the design and analysis.

TE 336 Fabric Technology I (2-2)3

This is designed to familiarize the sudent with the mechanism associated with single woven fabric production. Involved are the complexities of cams, kinetics, pulleys, cones, linkages, etc. as related to simple automatic looms and structures produced thereon.

TE 363 Textile Systems II (3-1)3
[TE 264]

Same as TE 264 but involving wool in woolen or worsted yarn systems or blends of same with natural and synthetic fibers. A consideration of recovery processes for use of waste in varied fabrics in included.

TE 365 Textile Systems III (3-2)3
[TE 264]

The concepts of fabric design: an analysis of the effects of mechanical processing upon structural relationships, with stress on physicomechanical and chemical behavior.

TE 366 **Textile Systems IV** **(3-2)3**
[TE 365]

A study of the more complex woven structures including jacquards, double fabrics, etc.

TE 411 **Technology of Yarns I** **(2-2)3**
[TE 212]

A comprehensive coverage of the basic engineering principles, machines and techniques for the production of yarns on the cotton system from cellulosic and man made staple fibers.

TE 412 **Technology of Yarns II** **(2-2)3**
[TE 411]

Similar to TE 411 but covering the basic engineering principles, machines and techniques for the production of yarns from wool and man made fibers on the woolen and worsted systems including blends. The filament yarn processing system is also included as well as the study of textured yarns.

TE 431 **Fundamentals of Textiles — Fabrics I** **(2-2)3**

This subject is designed to familiarize students with the various systems of warp preparation, fundamentals of woven structures, various yarn numbering systems, and the basic cam equipment and techniques for the production of fabrics. Involved are the complexities of cams, kinetics, cones, linkages, etc., as related to plain automatic looms.

TE 432 **Fundamentals of Textiles — Fabrics II** **(2-2)3**
[TE 431]

This subject covers box and dobby weaving and includes single and double index, chains, timing and adjusting. Jacquard instruction covers single lift, double lift and double cylinder jacquards, and includes harness tie-ups, card cutting, timing and adjusting. Cotton, woolen, worsted and synthetic yarns are used. This subject also covers the various types of shuttleless looms presently available.

TE 433 **Technology of Knitting** **(2-2)3**
[Recommended as technical elective for those majoring in textile engineering]
[May be given either semester]

A broad survey of the mechanics of knitting equipment and the varied fabrics produced therefrom.

TE 437 **Fabric Technology II** **(2-2)3**
[TE 336]

A thorough study of design and weaving as applications of science to the construction of fabrics.

TE 457 **Technology of Finishing I** **(3-0)3**
[TE 366]

A lecture course in the conversion of greige goods of all contents through the drying stage subsequent to wet processing operations. The major objectives, methods, equipment, engineering principles, theory and anticipated results are both theoretically and practically analyzed.

TE 458 **Technology of Finishing II** **(1-2)2**
[TE 457]

Final operations necessary to the application, understanding, and evaluation of the processes, agents, etc., essential to produce an end product with hand, appeal, utility and serviceability are discussed, analyzed, and eventually effected in the laboratory.

TE 459 **Textile Systems V** **(2-1)2**
[TE 366]

A study and analysis of the physical behavior of gray fabrics as mechanical systems during the finishing operations. Major emphasis is on absorption, pressure, heat transfer, and the physical and mechanical design principles involved.

TE 460 **Textile Systems VI** **(1-2)2**
[TE 459]

The basic chemical structure of the fibers within the fabric and the relationship which such a system has with the application of dye and finish due to chemical transition catalysis, electrostatic attraction, covalent and other bonding forces, etc., in effecting an acceptable end product.

TE 472 **Textile Evaluation** **(2-3)3**
[TE 365 or equivalent]
[May be given each semester]

Devoted to the basic mechanical tools and techniques and their utilization by the textile industry for research, development, product control, and end use evaluation. Moisture equi-

librium and rates of change relations; basic fiber, yarn, and fabric dimensions; spatial relations and fluid flow instrumentation; an introduction to the determination and evaluation of the stress-strain-time properties of viscoelastic fibrous structures; and wear or abrasion of textile structures are among the topics considered.

TE 474 Instrumentation for Textiles (2-2)3
[PH 102 or equivalent]

A study of some mechanical, electrical, and electronic methods for the measurement and control of such common textile process variables as pressure, temperature, liquid level, and fluid flow. The response of sensing elements, the modes of control, the characteristics of final control elements, and the interrelationship between those in closed loop systems are considered.

TE 482 Application of Scientific Methods to Textile Processes (3-0)3
[PH 201, MA 203, ME 216]

A cross-discipline course which exercises the student in the application of his knowledge of science and engineering to problems of textile processing. In problem-solving sessions, an effort is made to simulate the resources and on-the-job environment of a practicing textile engineer.

TE 483 Engineering Design of Textile Structures I (3-0)3
[MA 203 and TE 335 or TE 365]

This subject correlates engineering properties of textile materials, engineering principles and textile methods in the design of textile structures with desired properties. Considered, are the following: the geometry and design of yarns for certain functional uses; prediction of dimensional changes which occur during use; stresses, strains, and energy changes imposed by end use; and analyses of load-elongation diagrams of fibers and yarns.

TE 484 Engineering Design of Textile Structures II (3-0)3
[TE 483]

This subject deals primarily with three dimensional textile structures. The concept and objectives of the course are similar to that of TE 483. In addition, metallic fabrics and graphical solutions are considered.

TE 485 Statistical Quality Control — Textile (3-0)3
[MA 383, TE 431 or equivalent]

A study of statistical and administrative techniques relevant to the maintenance of product quality at defined levels. Sampling plans for variables and attributes are considered from the viewpoint of engineering economics.

TE 495 Senior Project 3

This is an in-depth study or senior thesis on an acceptable topic and directed by a staff member.

TE 503 Technology of Novel Cellulosic Substrates (2-2)3
[Permission of Instructor]

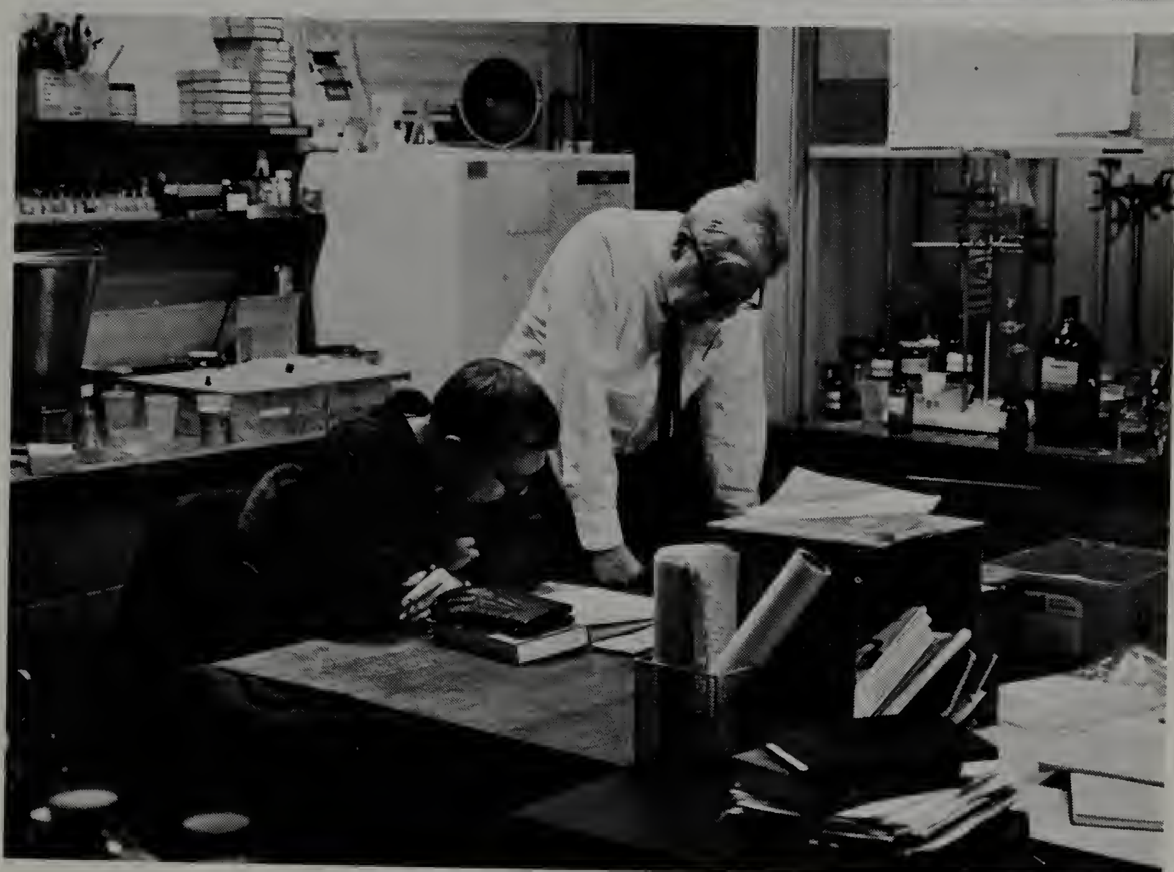
Systems for handling and methods of utilizing cotton waste products, modified cottons, non-woven textile structures in the production of novel fabrics. The effects of various chemical, mechanical and growth modifications of cotton on the chemical, physical and processing properties of cotton fiber. Problems are assigned for laboratory evaluations and a written report for oral presentation is required.

TE 585 Textile Plants Organization — Yarns (3-0)3
[Permission of Instructor]

Designed to correlate the various aspects of yarn production. Emphasis is placed upon the need for proper balance among machinery elements for the production of specific yarn types. Consideration of machinery layouts for efficient and economic operation of the total yarn establishment, with stress on the various calculations involved. Considerable use is made of the case history technique of presentation.

TE 587 Textile Plants Organization — Fabrics (3-0)3
[Permission of Instructor]

Similar in concept to TE 585 except that the subject pertains to the production of fabrics.

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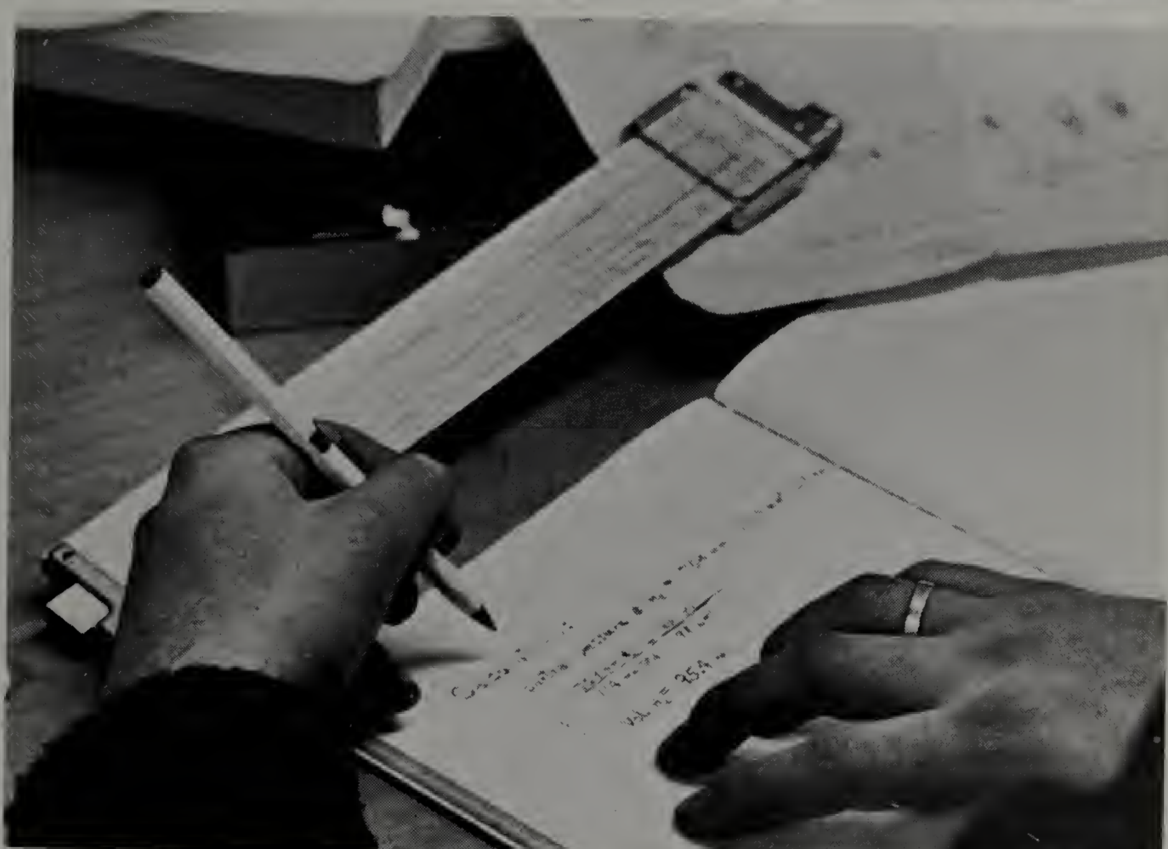

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